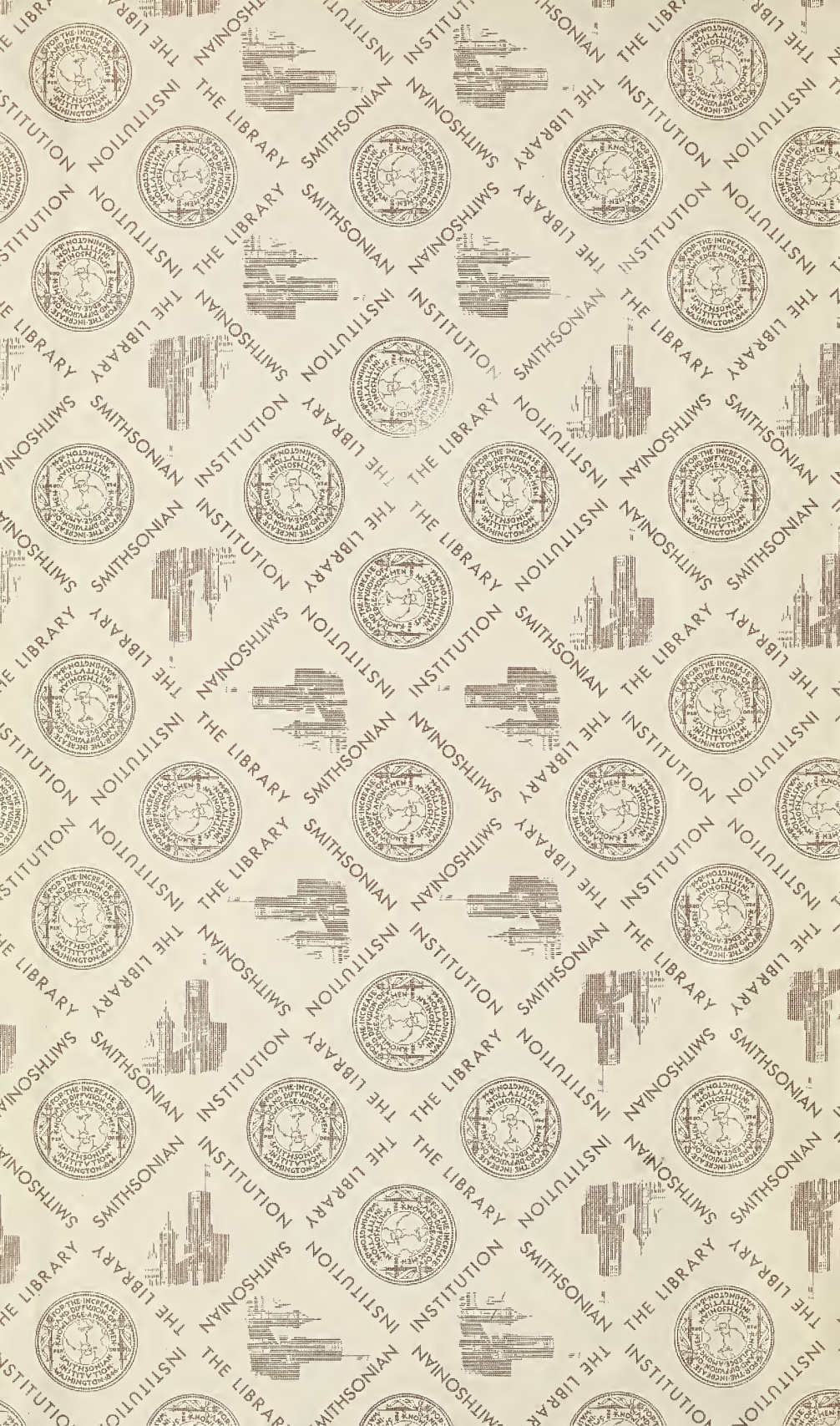
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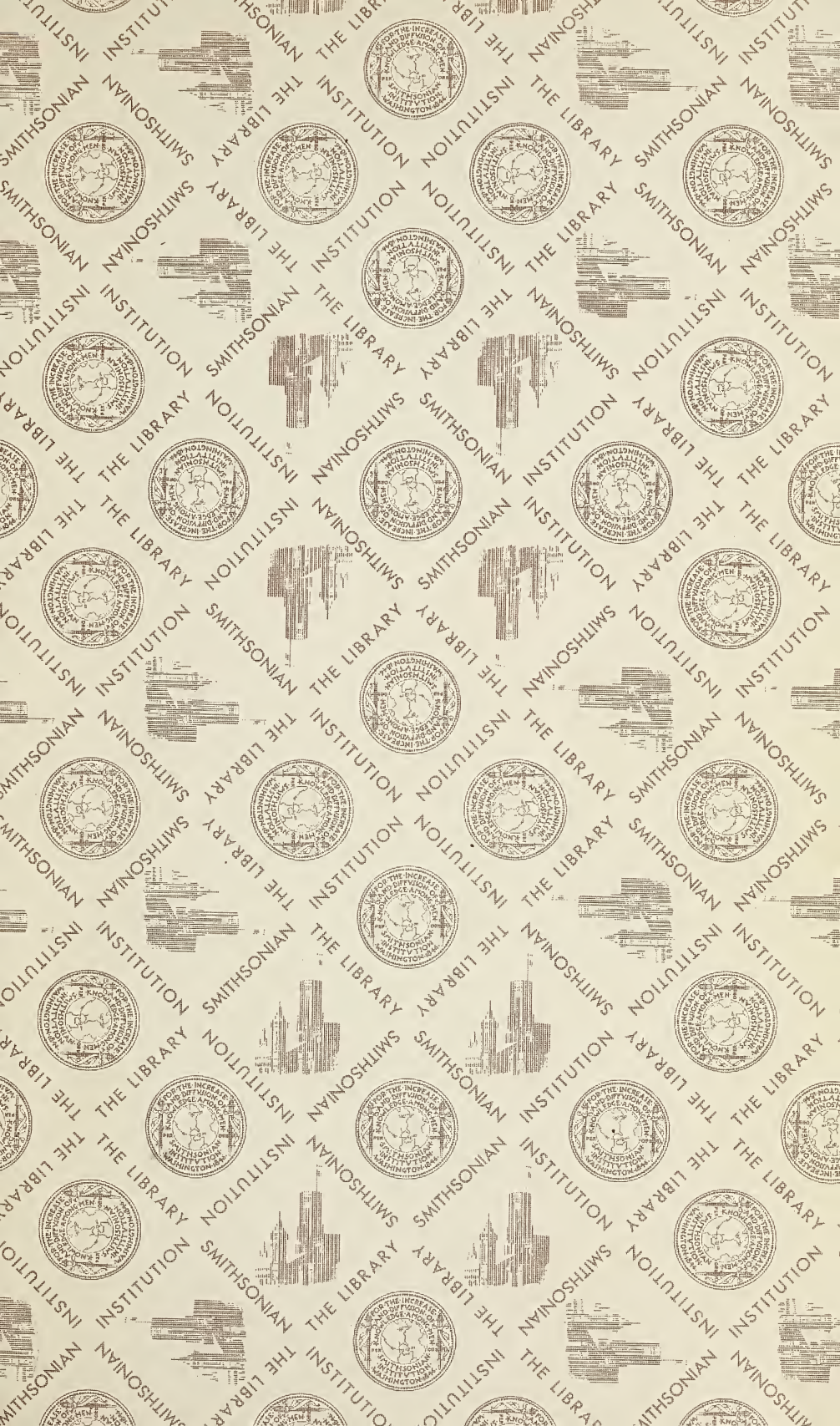
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New York State Museum Bulletin

Published by The University of the State of New York

No. 324 ALBANY, N. Y. June 1941

NEW YORK STATE MUSEUM

CHARLES C. ADAMS, *Director*

THE SALAMANDERS OF NEW YORK

By

SHERMAN C. BISHOP Ph.D.

Professor of Zoology in the University of Rochester

Formerly Zoologist, New York State Museum

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INTRODUCTION

The information and records upon which this report is based have been brought together during the past 20 years as opportunities have been found and other duties permitted.

No detailed account of the salamanders of New York has ever been given. DeKay, 1842, included the salamanders in his report on the reptiles and amphibians of the State, but limited his treatment of the group to brief descriptions and notes. A catalog of the reptiles and amphibians of New York, compiled by Eckel and Paulmier, was published as a bulletin of the New York State Museum in 1902, but no attempt has been made to bring together in one place an account of the life history, habits and distribution of all the species.

Local lists of species and reports covering limited areas have appeared from time to time and have provided helpful notes and many records. These include the reports by Eights, 1835–36, and Bishop, 1923, for Albany county; the report on a collection made at Coxsackie, N. Y., by Baird in 1852; the lists of Davis, 1884, and Wilmott, 1933, for Staten Island; the lists and reports of Sherwood, 1895, Ditmars, 1905, and Noble, 1927, for the New York City region; Britcher, 1903, for Onondaga county; Deckert, 1914, for Westchester county; Evermann, 1918, and Weber, 1928, for portions of the Adirondacks; Wright and Moesel, 1919, for Wayne and Monroe counties; Bishop, 1927, for Allegany State Park; and Myers, 1930, for the Palisades Interstate Park.

Various faunal works have included the salamanders, and among these may be mentioned the report of Bicknell, 1882, on the Catskill mountains, that of Mearns, 1898, on the Hudson Highlands and of Reed and Wright, 1909, on the Cayuga Lake basin.

DeKay (1842) listed 18 species, 16 of which were reported from the State and two from adjoining areas. Of the names applied to the 16 supposed species, three, *Salamandra symmetrica, S. coccinea* and *Triton millepunctatus,* refer to the common newt, *Triturus v. viridescens,* and two, *Triton porphyriticus* and *Salamandra glutinosus,* to the slimy salamander, *Plethodon glutinosus.* Among the remaining species may be recognized the following in the order given: *Salamandra subviolacea* (=*Ambystoma maculatum*); *S. erythronota* (=*Plethodon cinereus*); *Salamandra salmonea* (=*Gyrinophilus porphyriticus*); *S. fasciata* (=*Ambystoma opa-*

cum); *S. longicauda* (=*Eurycea longicauda*); *S. granulata* (possibly *Ambystoma jeffersonianum*); *S. bilineata* (=*Eurycea b. bislineata*); *S. ruber* (=*Pseudotriton ruber*); *Triton tigrinus* (=*Ambystoma tigrinum*); *T. niger* (possibly *Desmognathus f. fuscus*); *Menobranchus lateralis* (=*Necturus maculosus*); and *Menopoma alleghaniensis* (=*Cryptobranchus alleganiensis*). Altogether, 14 species may be recognized with some degree of certainty among those listed by DeKay from New York.

Eckel and Paulmier (1902) also listed 18 species of which 16 are valid. Two of the 16 species, the hellbender, *Cryptobranchus alleganiensis,* and the four-toed salamander, *Hemidactylium scutatum,* are mentioned as, "probably found in the State," although they had been definitely recorded many years before.

The earliest mention of a salamander from New York waters is apparently that of Schneider (1799), who described but did not name the mudpuppy, *Necturus,* from Lake Champlain. Since the specimen was taken on the Vermont side of the lake perhaps the type description of *Ambystoma opacum,* Gravenhorst, 1807, should stand as the first New York record and Mitchill's 1822 account of *Necturus* from Black Rock, now a part of Buffalo, as the first mention of that species in the State.

The newt, *Triturus viridescens,* was described by Rafinesque in 1820 from Lake Champlain and Lake George, and in the same paper, *Desmognathus fuscus,* from the "Northern parts of the State of New York."

The spotted salamander, *Ambystoma maculatum,* was recorded by Green from the vicinity of Albany in 1827, under the name *Salamandra subviolacea.* James Eights, at Albany, added *Salamandra bislineata* (=*Eurycea bislineata*) in 1835 and the following year *Salamandra erythronota* (=*Plethodon cinereus*), *S. ruber* (=*Pseudotriton ruber*) and *S. tigrina* (=*Ambystoma tigrinum*). The long-tailed salamander, *Eurycea longicauda,* is reported by DeKay, 1842, and Holbrook, 1842, as having been seen by Green in the vicinity of Albany. DeKay also added *Triton porphyriticus* (=*Plethodon glutinosus*) from the vicinity of New York city, *Salamandra salmonea* (=*Gyrinophilus porphyriticus*) from Newcomb, Essex county, and *Menopoma alleghaniensis* (=*Cryptobranchus alleganiensis*) from the Allegheny river; the last mentioned on the authority of James Hall. DeKay may also have been responsible for the first record of *Ambystoma jeffersonianum* in the State, if one can recognize this species in his description of *Salamandra granulata* from northern New York.

The four-toed salamander, *Hemidactylium scutatum*, was added to the fauna of the State by Baird in 1850, when specimens were collected by LeConte in New York City. The Allegheny salamander, *Desmognathus ochrophaeus*, was added by Cope in 1869, the records based on specimens from Allegany county. After a lapse of 58 years, *Plethodon wehrlei* was collected at Allegany State Park and the record published by the writer in 1927.

A uniform treatment of the various species has been attempted, in so far as the character of the subject and information concerning it would permit. The accounts give the average and maximum size attained by a species, its structural features, the usual colors, patterns and variations. Under the general heading "Activities of the Breeding Season" notes are given on migration, mating, spermatophores, nests, the egg laying process and egg clusters. Under the heading "Development" accounts are given of the egg and its envelops, the period of incubation, the newly hatched larva, the larval period and subsequent development to maturity. Separate paragraphs have been devoted to habits, including food and feeding, and to a discussion of the habitat. Under "Remarks" I have included items of a historical character and comments. The range of each species is given, quoted directly from Stejneger and Barbour's "Check-List," except where supplemented by my own records. The general distribution within the State is outlined, based on the specific records which are given in full. The condensed bibliography accompanying each account gives references to the literature pertaining to life history and habits and distribution in the State.

In the records accompanying the account of a species, which, for convenience, have been arranged alphabetically by counties, I have included the collector's name in parentheses. When the record has been taken from a published account, the year of publication is given following the author's name. Where the specimens have been found in museum collections, the name of the institution has been indicated and the catalog number given when known. Where no collector's name follows a record, the writer is responsible. The collector has usually been indicated by his initials and a list of those who have contributed specimens is appended for identification.

In the condensed bibliography, the name under which the species was recorded has been added (where it differs from that in the reference just preceding), but no attempt has been made to present the complete synonymy. For convenience, the authors' names have been arranged alphabetically and the complete title of any publication cited may be found in the bibliography at the end of the report.

In making use of the observations of others, I have paid particular attention to those accounts which deal with the species in the more northern parts of its range because of the difference in habits, habitats and in the rate of development in the different parts of the range of a widely distributed species. My own observations are believed to be reliable for the particular time and place; they may not be for some other part of the country.

Seventeen species, representing ten genera distributed among five families, are found in the State. One additional species, *Pseudotriton montanus*, has been recorded based on a single specimen in the American Museum of Natural History, and said to have been taken at Orangeburg. There is very little reason to believe the species is native to New York and considerable circumstantial evidence to indicate that the specimen was mislabeled. G. K. Noble and others have collected carefully at the locality from which the specimen was recorded but without success.

If any justification is needed for the publication of the detailed records accompanying the accounts of the species, it is to be found in the rapidly changing conditions which, in various parts of the State, have brought about the extermination of certain species over wide areas. These changes may be expected to continue and exert an ever-increasing pressure as swamps and marshes are drained, and the land cleared.

In some instances, the records and maps provide an accurate view of the distribution of a species. This is true of *Cryptobranchus alleganiensis,* which is limited to the Allegheny and Susquehanna rivers and their tributaries in New York; it is not true of such species as the newt, *Triturus v. viridescens,* which is without doubt, to be found in every county of the State, although records for several are lacking.

Acknowledgments. This study of the New York salamanders was initiated at the New York State Museum, where, in the capacity of Zoologist, I received the support of the late director, Dr John M. Clarke and the present director, Dr Charles C. Adams. It was completed at the University of Rochester.

The salamanders in all the principle museums and collections in the East have been studied at one time or another and the records thus obtained are believed to be complete, at least to the time of my visits.

For permission to study the specimens I would express my appreciation to the authorities in charge of collections of the United States

National Museum; the American Museum, New York; the Museum of Comparative Zoology, Cambridge; the Academy of Natural Sciences of Philadelphia; the Boston Society of Natural History; the Brooklyn Museum; the Staten Island Institute of Arts and Sciences; the Roosevelt Wild Life Forest Experiment Station, Syracuse; Cornell University, Ithaca; Syracuse University; and Hobart College, Geneva.

The photographs accompanying the report are, for the most part, original; a few have appeared in earlier reports of the writer. They have been taken at various times and places and, except where otherwise credited, have been made by myself. The drawings in black and white have been made under my direction or by myself. The water color drawings, here reproduced in black and white, are the work of a number of artists working independently or attached at times to the New York State Museum and the University of Rochester. The drawings have been made whenever the artist, specimen and funds have been available at the same time. Under these circumstances it has often been impossible to plan in advance for the completed plate and the drawings finally assembled may represent the work of several artists spread over a period of a dozen years. In a few instances, when some particular specimen had been found and neither artist nor means to secure one were at hand, I have painted it myself.

The larger number of water color drawings were made by Hugh P. Chrisp and Mrs Esther K. O'Brian, of Albany, N. Y.; a few by Helen Rearwin, staff artist of the Department of Zoology, University of Rochester. For the careful way in which most of their work has been done, I would express my grateful thanks.

Those who have permitted me to make use of field notes and records and who have contributed specimens at various times have added materially to the completeness of the several accounts, and it is a pleasure to acknowledge my indebtedness. In particular should be mentioned Dr A. H. Wright, Cornell University; Dr E. R. Dunn, Haverford College; M. Graham Netting, Carnegie Museum; Dr Francis Harper, Swarthmore, Pa.; the late Dr Frank N. Blanchard, University of Michigan; Jay A. Weber, Leonia, N. J.; the late Dr G. K. Noble, American Museum; Roy Latham, Orient, N. Y.; Dr Frederick J. Holl, University of Buffalo; Dr R. R. Humphrey, University of Buffalo; Dr Leo Murray, Baylor University, Waco, Texas; Richard Brown, Port Allegany, Pa.; and Dr William J. Koster, University of New Mexico, Albuquerque, N. Mex.

One is always in debt to friends who have been companions in the field. Their interest, help and encouragement have lightened the often arduous tasks and contributed materially to whatever value may be attached to this report. For their helpful companionship I would thank Dr A. H. Wright, Cornell University; Prof. Barnard S. Bronson, New York State College for Teachers, Albany; Hugh P. Chrisp, Albany; W. J. Schoonmaker, New York State Museum; Richard C. Hart, Rochester; and my students and associates at the University of Rochester.

Especial thanks are due Helen M. Zorsch of Rochester for the constant aid she has given in the preparation of drawings and maps.

List of Collectors and Institutions

Academy of Natural Sciences of Philadelphia	A. N. S.
Adams, C. C.	C. C. A.
Alexander, C. P.	C. P. A.
Alexander, W. P.	W. P. A.
Allen, A. A.	A. A. A.
American Museum of Natural History	A. M. N. H.
Bailey, R. M.	R. M. B.
Bishop, Alice S.	A. S. B.
Blatchley, Myrtice	M. B.
Boston Society of Natural History	B. S. N. H.
Bronson, B. S.	B. S. B.
Brooklyn Museum	Brook. Mus.
Carnegie Museum	C. M.
Chrisp, H. P.	H. P. C.
Coker, R. E.	Coker
Cornell University	C. U.
Corrington, J. D.	J. D. C.
Crosby, C. R.	C. R. C.
Davis, W. T.	W. T. D.
Engelhardt, G. P.	G. P. E.
Greeley, J. R.	J. R. G.
Hall, M. A.	M. A. H.
Hamilton, W. J.	W. J. H.
Hankinson, T. L.	Hankinson
Hough, H. B.	Hough
Hudson, H. G.	Hudson
Humphrey, R. R.	R. R. H.
Lagler, Karl	K. L.
Latham, Roy	R. L.
Leffingwell, D. D.	D. D. L.
Museum of Comparative Zoology, Cambridge	M. C. Z.
New York State Museum	N. Y. S. M.
Schoonmaker, W. J.	W. J. S.
Roosevelt Wild Life Forest Experiment Station, Syracuse	R. S.
Royal Ontario Museum	Royal Ont. Mus.
Staten Island Institute of Arts and Science	S. I.
Stone, U. B.	Stone
Syracuse University	S. U.
United States National Museum	U. S. N. M.
University of Michigan	U. M.
University of Rochester	U. R.
Van Auken, Robert	VanAuken
Weber, J. A.	J. A. W.
Wright, A. H.	A. H. W.
Wright, Margaret R.	M. W.

PART I

THE IDENTIFICATION OF SALAMANDERS, THEIR LARVAE AND EGGS

The adults of most New York salamanders are sufficiently distinct in size, form, color or pattern to be easily recognized. A few, such as the dusky salamander, *Desmognathus fuscus fuscus,* the Allegheny salamander, *D. ochrophaeus ochrophaeus,* and the two-lined salamander, *Eurycea bislineata bislineata,* are confusing at times but should not offer serious difficulties. To aid in the interpretation of some of the terms used in the keys and descriptions, reference may be made to the labeled diagram (figure 1) and the diagrams of the mouth parts (figures 2–3).

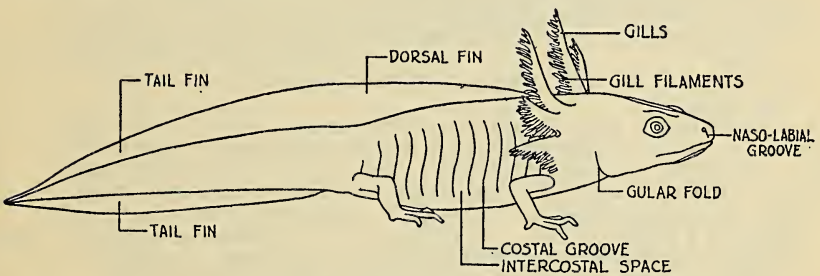

Fig. 1 Diagrammatic outline of salamander to show location of some structural features mentioned in descriptions and keys.

The arrangement of the teeth and the size, shape and attachment of the tongue differ in the various species and offer valuable clues to their identity.

The larvalike teeth of *Necturus* and *Cryptobranchus* are mostly anterior to the inner nares. In *Ambystoma* the parasphenoid teeth are lacking and the vomerine teeth form transverse series. In *Gyrinophilus* and *Pseudotriton* the vomerine and parasphenoid series are continuous, while in *Plethodon, Hemidactylium, Eurycea* and *Desmognathus* they are separate. In *Hemidactylium* a few teeth on the premaxillae are enlarged in the male and sometimes perforate the lip. In adult males of *Desmognathus,* as the genus is represented in New York, the vomerine teeth are usually lacking. In *Triturus* the series of teeth on the palate are in two lines converging anteriorly.

The tongue in *Necturus* and *Cryptobranchus* is thick and fleshy; in *Ambystoma* broad and flat; in *Plethodon, Desmognathus* and *Hemidactylium* it is smaller, attached medially in front and has the sides and posterior margin free; in *Eurycea, Pseudotriton* and *Gyrinophilus* it is attached by a slender pedicel; and in *Triturus* it is very small and only slightly free along the sides.

The key to the species of New York salamanders is primarily for the identification of adults, but a sufficient number of characters has been introduced to help in the discrimination of younger specimens.

Key to the Species of New York Salamanders

Adults

		PAGE
1	With three pairs of bushy, external gills; toes 4-4; permanently aquatic; size large, 12–17 inches ..... *Necturus m. maculosus*	18
	Adults normally without gills; if present very short, not bushy	2
2	Sides of trunk and hind margin of legs with a fleshy fold; a single pair of open gill slits; toes 5-4; permanently aquatic; size large, 15 to 27 inches ..... *Cryptobranchus alleganiensis*	37
	No fleshy fold on trunk or legs; usually no open gill slits; size small to medium	3
3	A dorso-lateral series of black-bordered crimson spots; ground color above brown to olive-green; belly yellow, black-specked; skin smooth, tail keeled (aquatic adults); or, ground color dull, reddish brown to bright orange-red, skin rough, tail oval (terrestrial stage); vomero-palatine teeth in two lines converging anteriorly; length 2½ to 4 inches ..... *Triturus v. viridescens*	54
	No dorso-lateral series of black-bordered crimson spots; vomerine teeth in transverse series or in lines curving inward and backward	4
4	Vomerine teeth in transverse series; no parasphenoid teeth; no naso-labial grooves; tongue large, fleshy, free behind and at sides only	5
	Vomerine teeth in series curving inward and backward (if lacking, as in some adult males, then hind legs conspicuously larger than fore, Desmognathus); parasphenoid teeth in one or two patches; naso-labial groove present; tongue small, attached at front or by a central pedicel	8
5	Size small to moderate, 3½ to 6½ inches; ground color dark with white cross bars on trunk and tail; or, with pale bluish white flecks of irregular size mainly confined to the sides	6
	Size moderate, 7 to 9+ inches; ground color dark, marked above with rounded yellow or orange spots; or with irregular, grayish yellow or greenish yellow blotches on sides and back	7
6	Moderately long and slender, ground color above bluish black to uniform dark brown, with or without small, irregular, pale bluish white fleckings mainly confined to sides; length to 6½ inches (eastern New York); or, general color darker, light fleckings more conspicuously developed, smaller, length to 5½ inches (western New York) ..... *Ambystoma jeffersonianum*	82
	Adults short and stout; ground color deep lustrous black, with white or grayish white transverse bands on trunk and tail, the bands widened on the upper sides, narrowed dorsally and often inclosing a series of large black spots; length to 4¾ inches ..... *Ambystoma opacum*	134
7	Ground color above deep bluish black; sides and venter lighter, slate color; marked above with two irregular rows of rounded spots dull yellow to bright orange; length to 7¾ inches .. *Ambystoma maculatum*	108

a

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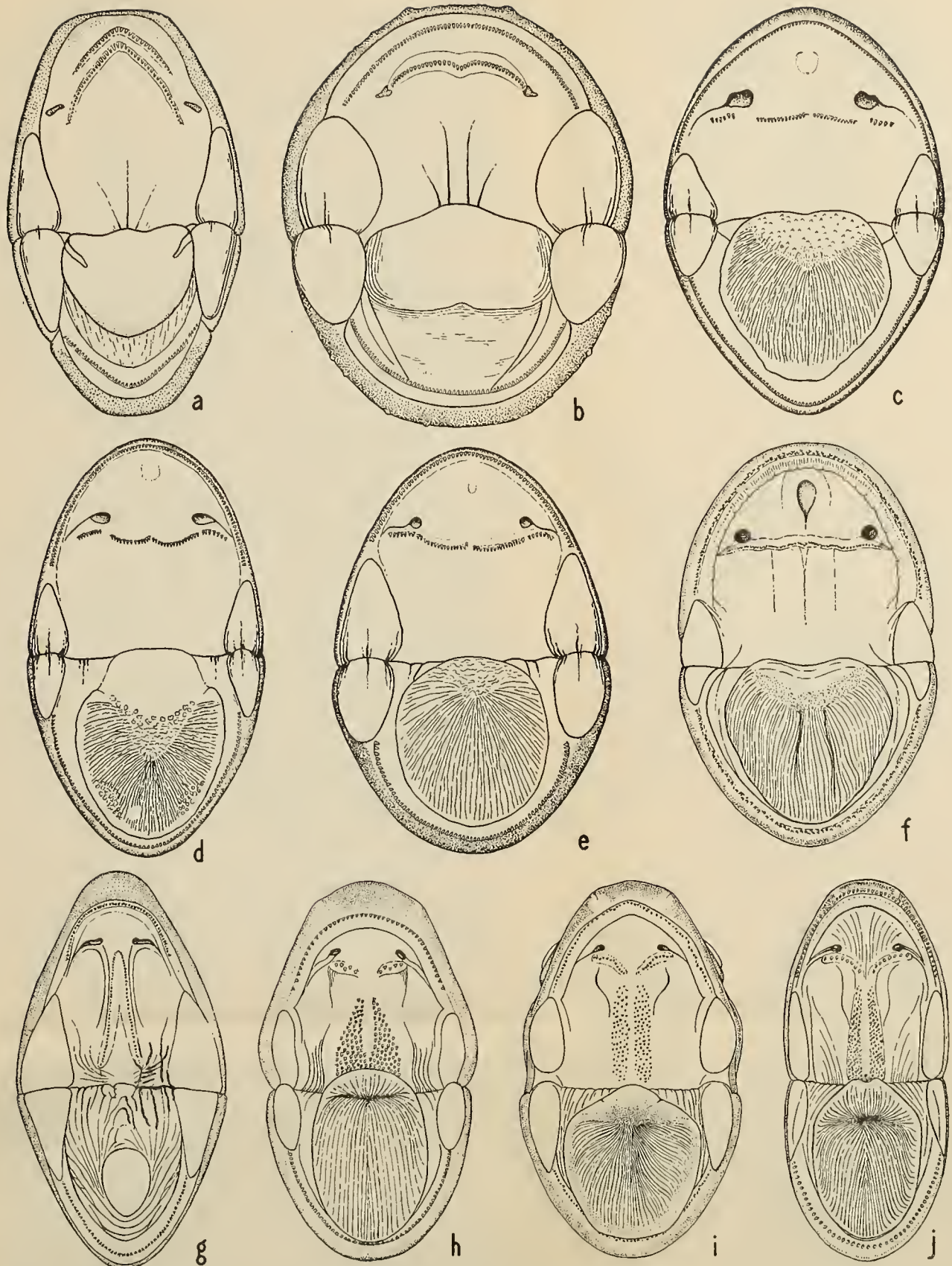


Fig. 2 Mouth structures of New York salamanders

a. *Necturus m. maculosus*
b. *Cryptobranchus alleganiensis*
c. *Ambystoma jeffersonianum*
d. *Ambystoma opacum*
e. *Ambystoma maculatum*
f. *Ambystoma t. tigrinum*
g. *Triturus v. viridescens*, ♂
h. *Plethodon cinereus*
i. *Plethodon glutinosus*, ♂
j. *Plethodon wehrlei*, ♂

Drawn by W. J. S. and H. M. Zorsch.

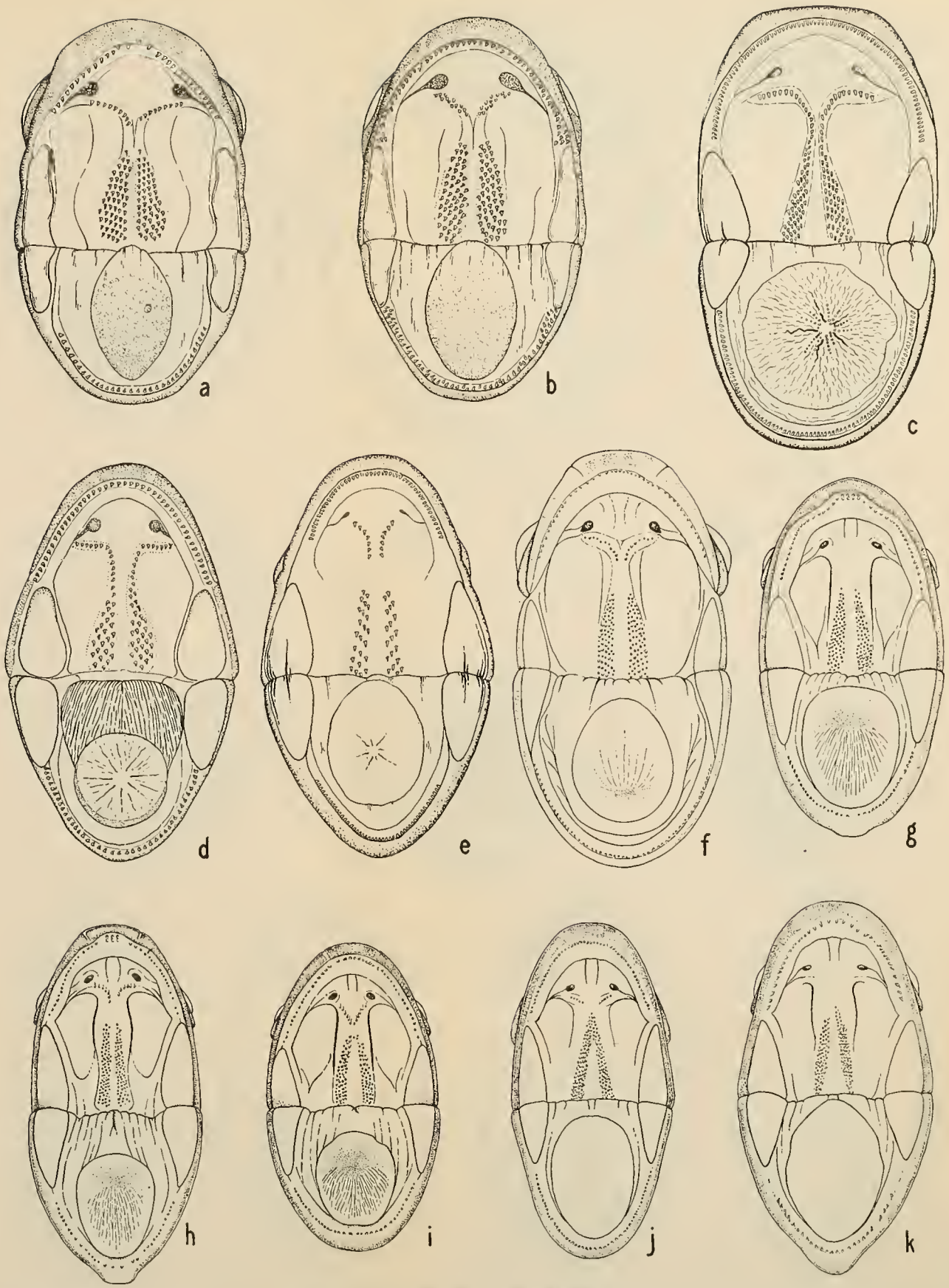
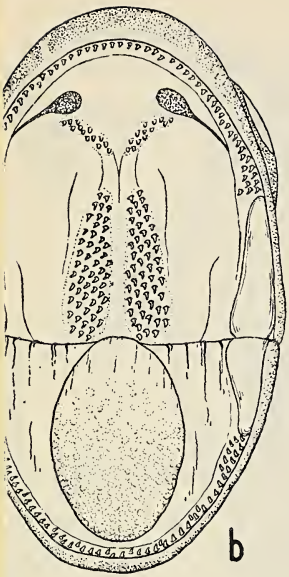


Fig. 3 Mouth structures of New York salamanders

a. *Hemidactylium scutatum*, ♂
b. *H. scutatum*, ♀
c. *Gyrinophilus p. porphyriticus*, ♀
d. *Pseudotriton r. ruber*
e. *Eurycea b. bislineata*, ♀
f. *E. longicauda*, ♀
g. *Desmognathus f. fuscus*, ♂
h. *D. f. fuscus*, 77 mm male with vomerine teeth
i. *D. f. fuscus*, ♀
j. *Desmognathus o. ochrophaeus*, ♀
k. *D. o. ochrophaeus*, ♂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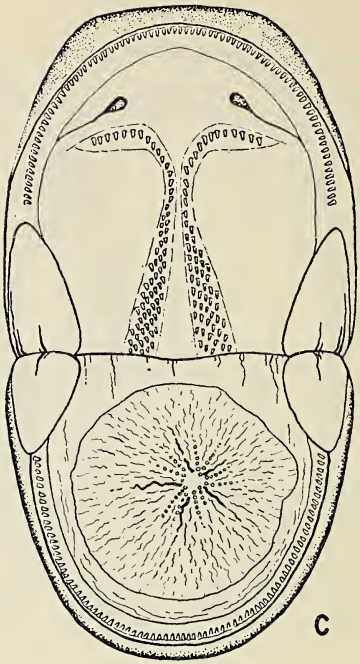
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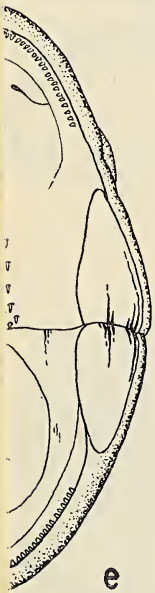
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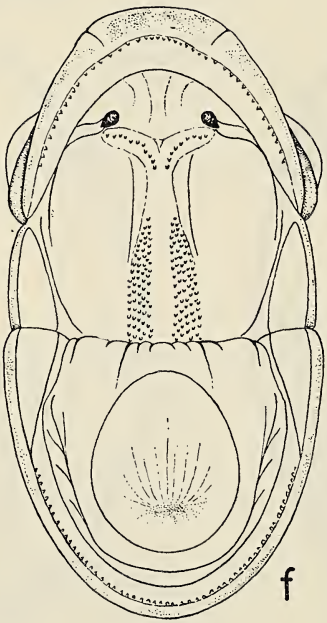
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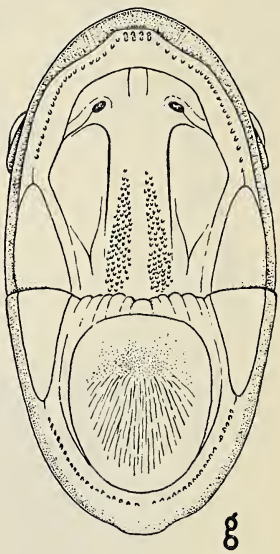
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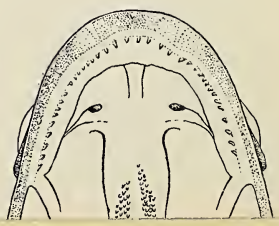

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Ground color above and on the sides deep brown to dull black; venter olive-yellow blotched with darker; marked on the sides and above with many pale olive-brown to brownish yellow blotches irregular in size and shape; length to 9¼ inches.....*Ambystoma t. tigrinum* 155

8 Toes, 4-4; tail with a basal constriction; belly bright white with many small, irregular jet black spots; length to 3½ inches.....
Hemidactylium scutatum 174

Toes 5-4; tail without basal constriction; belly not white with jet black spots 9

9 Tongue attached in front, tail rounded or trigonal..... 10

Tongue with a pedicel, tail compressed..... 14

10 A light line or bar from posterior angle of eye to angle of jaw; adult males usually without vomerine teeth; a single premaxilla; hind legs conspicuously larger than fore; semiaquatic or terrestrial.... 11

No light line or bar from posterior angle of eye to angle of jaw; adults with vomerine teeth; normally with two premaxillae; hind legs not much larger than fore; terrestrial..... 12

11 Tail rounded or oval in section, not keeled above; margins of median dorsal band usually straight; belly light gray, slightly mottled at sides; body comparatively slender; no series of small light spots on sides between fore and hind legs; length to 3¾ inches but usually smaller .....*Desmognathus o. ochrophaeus* 329

Tail trigonal in section; margins of dorsal band, when present, usually irregular; belly lightly pigmented and mottled; often with a row of small light spots on sides between fore and hind legs; length, average about 3½ inches, rarely to 4¾ inches.....*Desmognathus f. fuscus* 307

12 Costal grooves 18 or 19; a median dorsal stripe usually red but varying from light gray and dull yellowish to brick red (red-backed phase); or, uniformly lead-colored above with or without a faint indication of dorsal stripe (lead-backed phase); belly gray and white mottled (pepper and salt); length to 3½ inches.....*Plethodon cinereus* 196

Costal grooves 16; no median dorsal stripe..... 13

13 Ground color black or blue-black above and with many small, irregular silvery white spots scattered over the sides of head, trunk and tail and often over dorsal surfaces except snout and end of tail; length to 7½ inches.....*Plethodon glutinosus* 219

Ground color deep brown to almost black, lower sides bluish brown and flecked with irregular pale bluish white spots; belly uniformly light gray; length to 6 inches.....*Plethodon wehrlei* 232

14 Vomerine and parasphenoid series continuous; size 4 to 7½ inches. 15

Vomerine and parasphenoid series not continuous; length 3 to 6½ inches 16

15 A light line from eye to nostril; color salmon to purplish with darker mottlings, length to 7½ inches.....*Gyrinophilus p. porphyriticus* 239

No light line from eye to nostril; color coral-red to deep purplish brown with black spots; length to 5½ inches.....*Pseudotriton r. ruber* 259

16 Ground color yellow to pale brown; a light, median dorsal stripe limited on either side by a black dorso-lateral line; tail compressed; belly yellow; tail to 53% of length; in N. Y., length, average about 3 inches, rarely to 4 inches.....*Eurycea b. bislineata* 277

Ground color bright yellow or orange with black spots tending to form an irregular line along the midline of the back and along the upper sides; sides of tail, especially on basal half, with vertical, crescentic, black bars; belly yellowish along the sides; tail to 62% of length; length to 6½ inches.....*Eurycea longicauda* 297

Key to the Larvae of New York Salamanders

This key is designed to aid in the identification of larvae that have attained their full growth but may also be of help in determining partially grown specimens. The measurements indicate the size attained before transformation.

PAGE

1 Larvae small, 18 to 20 mm; terrestrial; larval period short..... 2
Larvae aquatic; small to large; larval period longer..... 4
2 With three pairs of separate, short, white gills; a broad, median light band; tail keeled above; length 18 mm..*Desmognathus o. ochrophaeus* 336
Larvae with gills broad and leaflike, three branches arising from a common base; tail not keeled..... 3
3 With a broad dorsal stripe lighter than upper sides; length 18+ mm; in caves or crevices of shale banks.....*Plethodon glutinosus* 226
Broad dorsal stripe pinkish or yellowish; length 20 mm; in old rotting logs or beneath stones.....*Plethodon cinereus* 208
4 With a dorsal keel extending nearly to the head; tail keeled above and below; gills usually long; still water or pond type..... 5
Without a dorsal keel; tail more or less keeled; gills usually short; when long then bright red and bushy; stream type larvae.... 10
5 Small, 30 to 40 mm, in neoteinic forms, to 75 mm; a dark line on side of head through eye; a row of white dashes on sides; a dorso-lateral series of pale spots, yellowish or reddish.....*Triturus v. viridescens* 66
Not as above; no dark line on side of head through eye..... 6
6 Larvae moderate to large, 50 to 125 mm long; head wide; gills long and often bushy; toes 5-4..... 7
Larvae small, 20 mm, slender; head not greatly widened; toes 4-4 *Hemidactylium scutatum* 186
7 Size to 125 mm; gills long and bushy; toes flat and pointed; transforms July to September.....*Ambystoma t. tigrinum* 167
Size moderate, 50 to 75 mm..... 8
8 Sides of trunk uniformly pigmented; tail fins lightly mottled; toes long and slender; length 48 to 75 mm; transforms July to September *Ambystoma jeffersonianum* 101
Sides of trunk and tail strongly mottled; toes not conspicuously long and slender 9
9 With a row of indistinct pale spots on upper sides; until fully grown, with fore legs longer than hind; transforms May to July; length 60 to 74 mm.....*Ambystoma opacum* 148
Without a row of pale spots on upper sides; hind legs longer than fore, transforms July to October; length 40 to 70 mm, average 51 mm *Ambystoma maculatum* 125
10 Gills short, white; keel of tail confined mostly to dorsal side; a broad, dark, dorsal stripe, within which a double row of round pale spots; a narrow, light, vertebral line; transforms, usually, May to July; length to 44 mm.....*Desmognathus f. fuscus* 320
Gills longer, not short and white, pigmented at least at base..... 11
11 With three pairs of bushy red gills; toes 4-4; a "permanent larva"; mature specimens with a ground color dark brown with darker spots; younger larvae with a median dorsal dark band bordered each side by a yellow stripe.....*Necturus m. maculosus* 28
Gill not bright red or noticeably bushy; toes 5-4..... 12
12 Sides of body and hind margin of legs with fleshy folds; snout broad and depressed; eyes small; transforms 100 to 130 mm *Cryptobranchus alleganiensis* 49
Sides of body and hind margins of legs without fleshy folds..... 13
13 Size small, to 68 mm; with a broad median dorsal light band..... 14
Size larger; to 135 mm; without a broad median dorsal light band 15
14 With dorso-lateral rows of light spots, distinct in younger larvae, often fused and indistinct in mature larvae; eye small; length to 68 mm *Eurycea b. bislineata* 288
A dorso-lateral black band and sometimes a narrow, black, vertebral line; eye large; length 50 to 60 mm.....*Eurycea longicauda* 302
15 Dorsal surface with ground color red to dark reddish brown; with many small scattered black spots; head short, size to 110 mm *Pseudotriton r. ruber* 270
Ground color pale with darker reticulations; no black spots; head long; size 105 to 135 mm.....*Gyrinophilus p. porphyriticus* 250

The recently hatched larvae of many species differ so markedly from the older ones that they can not be recognized by means of the key given above. To aid in their identification a separate key has been prepared. The terrestrial larvae of *Plethodon cinereus* and *P. glutinosus* retain the gills only a short time and are sufficiently described in the key above.

Key to the Recently Hatched Larvae

1 With a dorsal fin extending nearly to head; tail keeled above and below; quiet water or pond type larvae 2
Without a dorsal fin but with tail keeled; stream type larvae; or if terrestrial, with short white gills, not pigmented, and with legs developed 7
2 Balancers present at hatching; or if balancers lacking then with fore legs and toes well-developed 3
Balancers not present at hatching; front legs if indicated, with toes never well-developed 6
3 Size small, 7.5 mm; ground color yellow with a dark stripe each side of dorsal keel; buds of fore legs elongate; hind leg buds not developed ..... *Triturus v. viridescens* 65
Size larger, 12 to 20 mm; head broad, body strongly compressed 4
4 Fore legs well-developed; toes developed; buds of hind legs short but evident; gills long and bushy; balancers sometimes lost before hatching; general color brownish without conspicuous markings *Ambystoma opacum* 144
Fore legs represented by buds; buds of hind legs not evident; balancers present, often retained 6 to 10 days 5
5 A dorsal pattern of large, paired dark spots; length 10 to 14 mm *Ambystoma jeffersonianum* 98
Without a dorsal pattern of paired dark spots; ground color greenish or brownish with many small, scattered dark spots; length 12–13 mm *Ambystoma maculatum* 123
6 Neither hind nor fore legs developed; a dorsal pattern of paired dark spots; often a faint lateral light stripe; length 13 to 18 mm *Ambystoma t. tigrinum* 164
Buds of fore legs elongate, usually with two digits indicated; buds of hind legs short; a light dorsal stripe with irregular, dark edges; length 11 to 14 mm, average 12.4 mm ..... *Hemidactylium scutatum* 184
7 A dorsal pattern consisting of a narrow, median, dark stripe bordered each side by a yellow stripe with irregular edges; upper sides dark; fore legs elongate, toes indicated; hind legs short, toes indicated; toes 4-4; length 27 to 32 mm ..... *Necturus m. maculosus* 28
Color pattern not as above; toes when indicated, 5–4 8
8 Gills short and white, not pigmented or, at most, lightly at base; fore and hind legs fully developed and with fingers and toes well-formed 9
Gills longer, well pigmented 10
9 A broad, dorsal light band with darker edges; terrestrial; length 18 mm *Desmognathus o. ochrophaeus* 336
A double row of rounded light spots within a broad, dark, dorsal band; a narrow light vertebral line; usually terrestrial for 10 days or longer, then aquatic; length 16.2 mm ..... *Desmognathus f. fuscus* 318
10 A median dorsal light band 11
Without a median dorsal light band 12
11 A series of small, rounded, light spots in the darker ground of upper sides; dorsal keel of tail abruptly elevated above the level of the back; eyes small; length 12–13 mm ..... *Eurycea b. bislineata* 287
12 Back and sides with a finely reticulated pattern; a narrow vertebral line, darker; head long; length about 25 mm ..... *Gyrinophilus p. porphyriticus* 248
Back and sides evenly pigmented 13

PAGE

13 Fore and hind limbs, elongate buds; toes not developed; hind margin of fore leg with a thin keel; eyes small; length 30 mm
Cryptobranchus alleganiensis 47

Fore and hind legs well-developed; toes developed or at least the digits indicated 14

14 Tail fairly long, bluntly rounded at tip; eye large..*Eurycea longicauda* 302

Tail shorter, not noticeably rounded at tip; head short; eye moderate; fore legs longer than hind.....*Pseudotriton r. ruber* 266

The difference in size, color and disposition of the eggs of New York salamanders has made it possible to construct a key by which they may be recognized. Not only are there differences in the egg clusters or masses, but in the number and thickness of the individual envelops (figure 4). In the diagrammatic drawings of individual eggs, the solid black center represents the yolk and the concentric lines the surrounding envelops. The lines simply indicate the outer limits of the major envelops of typical eggs and no account is taken of the minor subdivisions which may become apparent when eggs are fixed and sectioned. The diagrams also fail to show the character of the envelops. In some, a line may indicate the outer limits of a very thin envelop which incloses a thin and watery fluid; in others, the lines represent the limits of jelly-like layers of considerable consistency.

Key to the Eggs of New York Salamanders

PAGE

1 Eggs deposited in water..... 2

Eggs deposited in terrestrial situations..... 9

2 Eggs in a compact mass and provided with a common external envelop[1]; attached to sticks or aquatic plants in quiet water; eggs pigmented 3

Eggs not in compact masses with a common external envelop..... 5

3 Egg mass small, cylindrical, 1x2½" (25x60 mm); 7 to 40 eggs per mass, average 16; total complement to 286; common envelop comparatively thin, clear, never rigid; individual egg small, yolk 2 to 2.5 mm in diameter, with individual envelops to 4 mm; three, separate, fairly thin envelops.....*Ambystoma jeffersonianum* 97

Egg mass subspherical or kidney-shaped; medium to large, 50 to 100 mm long-diameter..... 4

4 Egg mass large, 2 to 3½ inches (50x90 mm) 60 to 256 eggs per mass; common envelop thick, rigid; clear, or opaque white; individual egg with yolk 2½ to 3 mm in diameter, with individual envelops to 6 mm; two separate envelops.....*Ambystoma maculatum* 121

Egg mass moderate to large; 2 to 3½ inches (50–90 mm); 23 to 110 eggs per mass; common envelop fairly thick, usually clear, rarely rigid, less dense than in *A. maculatum;* individual eggs with yolk 3 mm in diameter, with individual envelops to 8 mm; three separate envelops .....*Ambystoma t. tigrinum* 162

5 Eggs large, yolk 6 mm in diameter, with envelops to 20 mm; 300 to 450 in rosary-like strings deposited in excavations beneath stones in running water; not pigmented.....*Cryptobranchus alleganiensis* 47

Eggs not in a long rosary-like string..... 6

[1] Actually, the so-called "common external envelop" is the result of fusion of the outermost jelly layer which surrounds the individual eggs. This is clearly seen when single eggs are deposited and is often apparent when the egg mass is held to the light.

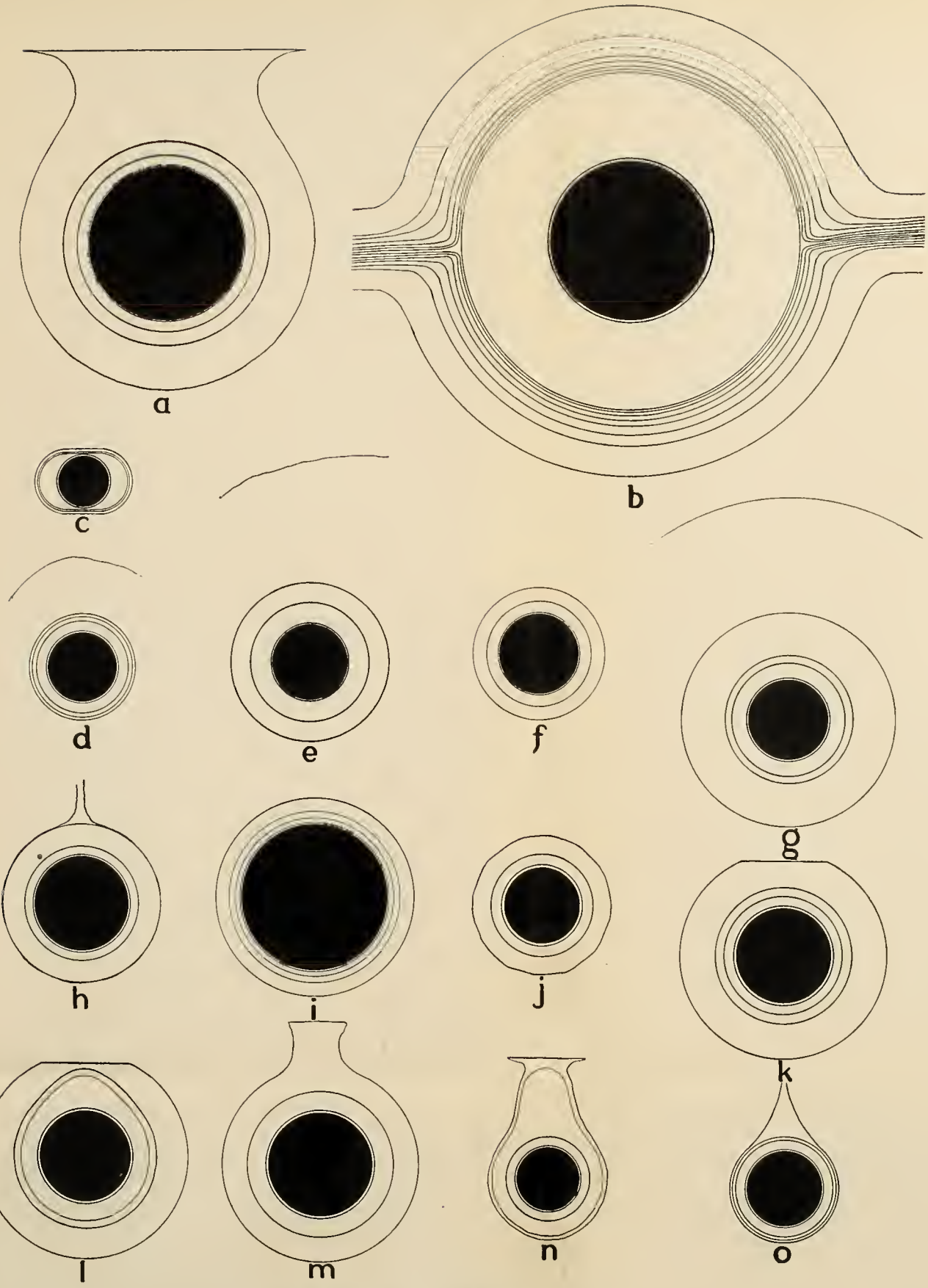


Fig. 4 Individual eggs of New York Salamanders, diagrammatic

a. *Necturus maculosus maculosus*
b. *Cryptobranchus alleganiensis*
c. *Triturus viridescens viridescens*
d. *Ambystoma jeffersonianum*
e. *Ambystoma maculatum*
f. *Ambystoma opacum*
g. *Ambystoma tigrinum*
h. *Plethodon cinereus*
i. *Plethodon glutinosus*
j. *Hemidactylium scutatum*
k. *Gyrinophilus porphyriticus porphyriticus* (recently deposited)
l. *Same, after 24 hours*
m. *Pseudotriton ruber ruber*
n. *Eurycea bislineata bislineata*
o. *Desmognathus fuscus fuscus*

PAGE

6 Eggs attached singly but clustered to the lower surface of a support in running water; without pigment..... 8
Eggs attached singly to leaves of water plants or rarely to stones; not clustered 7
7 Eggs small, yolk 1.5 mm; pigmented above greenish or brownish; with elliptical envelops, long diameter 3.5 mm, short diameter, 2.4 mm; 80 to 300 or more.....*Triturus v. viridescens* 65
8 Eggs large, yolk 5 to 6 mm, with envelops to 11 mm in diameter; 60 to 110 eggs; not pigmented.....*Necturus m. maculosus* 26
Eggs small to moderate with a slender attachment stalk..... 9
Eggs moderate, with yolk to 3.5 mm, with envelops to 9 mm (50 to 132 in number); no long slender attachment stalk, at least when deposited; three envelops; two middle envelops, pear-shaped *Gyrinophilus p. porphyriticus* 248
9 Eggs small, yolk 2½ to 3 mm, with envelops to 4.5 mm; a slender attachment stalk and flange-like attachment; eggs 18 to 43 in number; three envelops, middle one pear-shaped.....*Eurycea b. bislineata* 284
Eggs moderate in size, yolk 4 mm, with envelops to 6 mm; eggs 40 to 72 in number; with two envelops, none pear-shaped..... *Pseudotriton r. ruber* 265
10 Eggs deposited separately on land beneath rubbish, old logs, bark and leaves or in sphagnum moss; not attached to one another except as outer envelops adhere..... 11
Eggs deposited in small clusters, attached to one another or to a common pedicel 12
11 Eggs small, yolk 2½ to 3 mm, with envelops to 4½ mm; lightly pigmented above; 22 to 64 in number; deposited in moss or among the roots of grass at the edge of quiet pools; deposited during May attached to moss and one another by adhesiveness of outer envelop; two definite envelops, outer often irregular in thickness .....*Hemidactylium scutatum* 183
Eggs small, yolk 2.7 to 3 mm, with envelops 4 to 5.2 mm; 50 to 150 or more; deposited singly forming loose clusters beneath debris, old logs, or bark along the margins of slow streams or beneath moss and leaves in beds of dry ponds; two definite envelops, outer adhesive only when partially dry; deposited in the fall, September to October. *Ambystoma opacum* 142
12 Eggs attached to a common pedicel by which they are usually suspended 13
Eggs in compact clusters, attached to one another but not suspended 15
13 Eggs large, yolk to 5.5 mm, with envelops to 7.5 mm; 10 to 18 per cluster; attached to the side of little pockets in the walls of caves, in the south; not known in the north but probably deposited in deep recesses in shale banks; three envelops, outer fused with neighboring eggs but not drawn out into cord-like extensions; not pigmented. *Plethodon glutinosus* 225
Eggs small, yolk 3 to 3½ mm, not pigmented..... 14
14 Eggs small, yolk 3 to 3½ mm with envelops to 5 mm; 3 to 13 in grape-like clusters; deposited in rotten logs or rarely attached to lower surface of stone; individual eggs with two definite envelops and an outer layer of irregular mucous strands drawn together to form an attachment stalk; usually in moist or fairly dry situations..... *Plethodon cinercus* 206
Eggs small, with envelops to 4 mm in diameter; 10 to 14 in grape-like clusters, or, less frequently, deposited singly or in pairs; usually in little cavities beneath stones or logs where soil is saturated. *Desmognathus o. ochrophaeus* 336
15 Eggs small, yolk 2 to 2½ mm with envelops 3 to 4½ mm; 15 to 30 or more; in clusters in little excavations beneath stones, logs, moss or bark of rotten logs near streams or springs; attached to one another by extensions of outer envelop.....*Desmognathus f. fuscus* 317

PART II

THE LIFE HISTORY, HABITS AND DISTRIBUTION OF NEW YORK SALAMANDERS

NECTURUS MACULOSUS MACULOSUS (Rafinesque)

(*Sirena maculosa,* Amer. Month. Mag. Crit. Rev., 1818, 4: 41)

Mudpuppy, Waterdog, Water lizard, Dog fish

Figures *2a, 4a,* 5–8

The mudpuppy, our second largest salamander, has been known to zoologists since 1799; but every year it appears in the newspapers as the "strange animal unknown to science." It is widely distributed, abundant in many localities and is a classical subject in biological laboratories. It is perfectly harmless, as are all our salamanders, but is regarded as venomous by many fishermen and often destroyed in great numbers when taken during seining operations.

Description

Size. The average mudpuppy is about 12 inches in length. Twenty-five adults of both sexes taken at random from collections made in New York, Pennsylvania and Kentucky average 287.4 mm (about 11 5/16 inches). Specimens 15 inches long are not rare in large collections and exceptional individuals reach a length of 432 mm (17 inches). In the male, the tail comprises from 28.5 to 31 per cent of the total length; in the female, measurements of a considerable number of individuals indicate a wider variation, from 29.7 to 34.1 per cent of the length.

The proportions of a male 292 mm long are as follows: head length from snout to base of dorsal gills, 50 mm; width at widest point just in front of gills, 36 mm; tail from posterior end of vent, 84 mm; width 36 mm at widest point, which is 26 mm from tip; distance between legs, 116 mm; distance from rear of hind legs to hind margin of vent, 25 mm.

The females in any considerable series average a little larger than the males.

Form. The body is stout, depressed, and with a distinct median dorsal groove. The head is flat above and broadly swollen on the sides behind the eyes, then gradually narrowed to the truncated

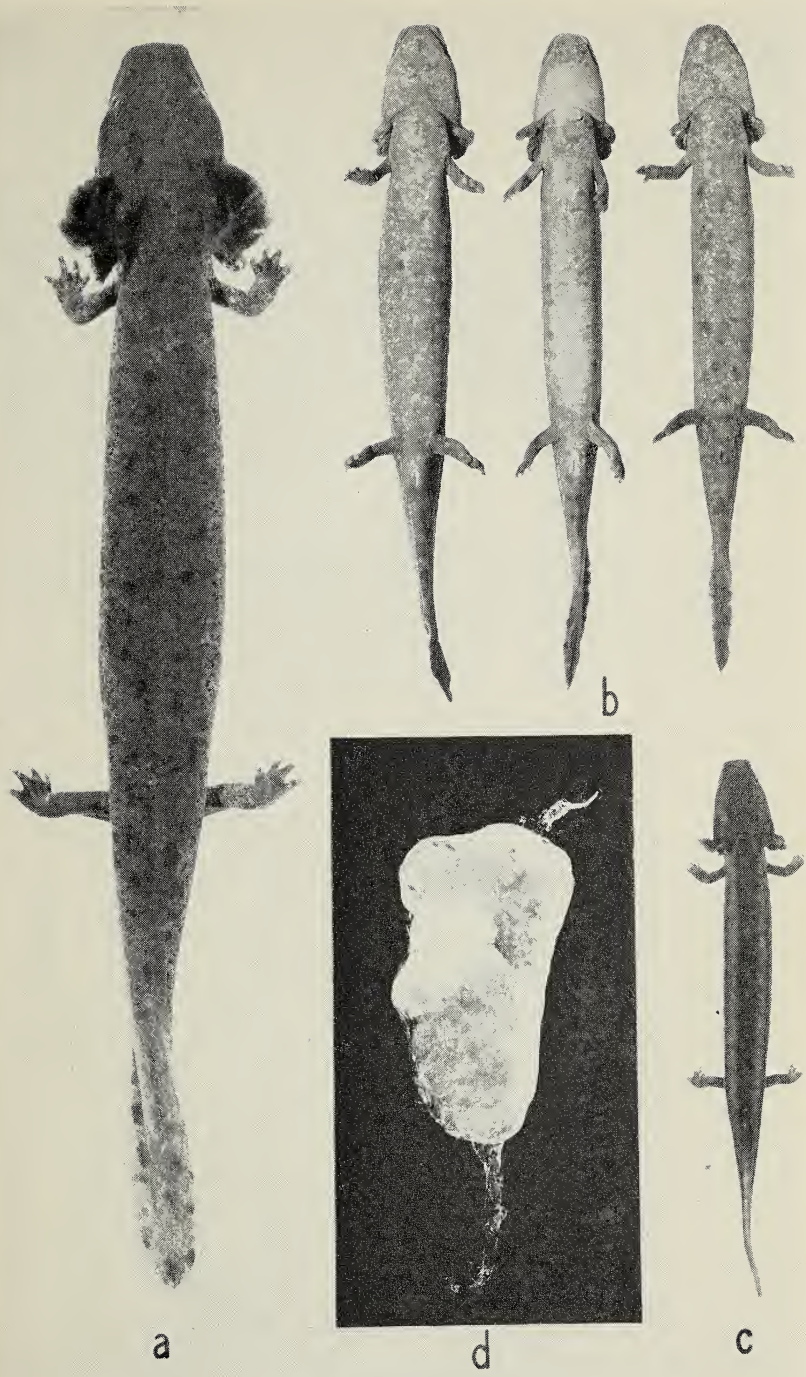


Fig. 5 a. *Necturus m. maculosus*, young adult in fifth year. Actual length, 190 mm. b. Four-year-old specimens to show variation in ventral color pattern. Actual length of largest, 150 mm. c. Two-year-old larva with dorsal stripes still apparent. Actual length, 84 mm. d. Spermatophore from male stimulated with pituitary extract.

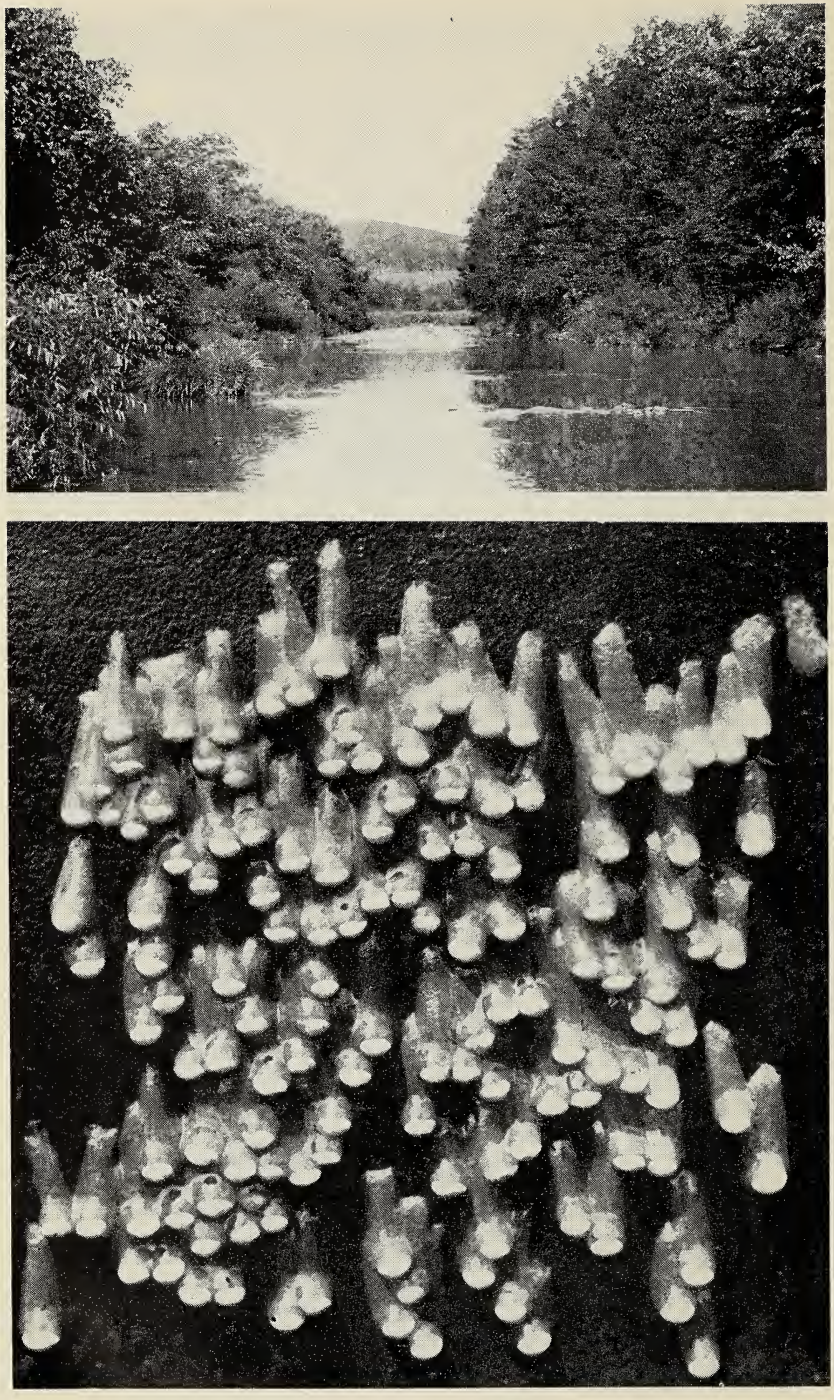


Fig. 6 Upper. Quaker Run, Allegany State Park, N. Y., habitat of *Necturus m. maculosus*. Lower. Eggs of *Necturus m. maculosus*, Woodcock creek, Saegertown, Pa., June 23, 1924.

snout. The eyes are small and round and not strongly protuberant as in many salamanders. The diameter of the eye goes into the head length about ten times. The mouth is moderately large and extends on the sides of the head to a point just back of the eyes. Along the sides, the upper margin of the lower jaw is provided with a deep groove and a free fleshy fold which is broadened anteriorly to form a rounded flap, visible from below even when the mouth is closed. On the sides of the upper jaw the fleshy margins are thin and turned inward to engage the groove of the lower jaw. This is essentially a "tongue and groove" arrangement which permits the mouth to be tightly sealed along the sides. The gular fold is strongly developed. The costal grooves number 15 counting axial and inguinal, but are sometimes hard to distinguish because of the general wrinkled condition of the skin of the sides. The permanent bushy gills are in three pairs on each side of the hind margin of the head. In the adult, the longest pair have the rachises about one-third the length of the head. With the flattened filaments fully distended with blood, the total length may reach one-half the head length. The blood supply of the filaments is under control and the length of the filaments varies considerably. When functioning, the gills are bright red and brushlike in appearance; when not in use, the gills are flattened to the sides of the neck, the filaments are much contracted and the color is dull red. The nostrils are small and placed near the angles of the truncated snout. The legs are short and stout, the toes 4-4, the innermost shortest; the others in order of their length 4-2-3. The toes taper slightly, and the tips are somewhat horny. The tail is strongly compressed, widest beyond the middle of its length and keeled above to a point opposite the vent.

The tongue is short, thick and fleshy with the anterior margin somewhat thinner and slightly free. The teeth are in two V-shaped series with the sides nearly parallel and apices directed forward. The premaxillary series is comparatively short, the vomero-palatine series longer and extending to the angle of the jaw. The inner nares are small, oblique slits placed outside of the vomero-palatine teeth and in front of the angle of the jaw.

Color. The color varies considerably, usually, however, in life the ground color is deep rust brown over blue black. Where the brown is absent the darker pigment strikes through to form rounded spots which vary in size from ⅛ to ⅜ of an inch in diameter. These spots may be irregularly disposed over the back, sides and belly or absent on the belly and lower sides. In a few individuals the spots

may be entirely absent giving this species the general appearance of *Necturus punctatus* Gibbes. Rarely, the spots may be developed in two fairly regular rows along the back and in these specimens there is often a lateral series. The upper surfaces of the legs are also usually spotted while the free margins of the tail are tinged with reddish or orange, particularly noticeable in young specimens. On each side of the head there is a dark bar extending through the eye to the gills. This bar may be well developed and conspicuous or short and indistinct. In some specimens the sides of the tail also retain a dark central area which, with the bar through the eye, probably represents the remnant of the dark lateral stripe of the young. The greatest variation is found in the coloration of the venter. In some, there is a broad central area free from dark pigment; others have the pigment uniformly distributed, and still others have dark spots on a dull ground.

Sexual differences. In general body form and color the sexes are alike. Measurements indicate that the head of the male may be slightly longer than that of the female, but the difference is too slight to be of value. Sex may be immediately determined by examining the vent. The vent in the male is a longitudinal slit, obliquely wrinkled at the margin, bounded posteriorly by a crescentic groove and provided with a pair of nipple-like papillae directed backward. The male vent is larger than that of the female and in the breeding season is surrounded by a swollen and inflamed ridge which marks externally the limits of the large cloacal gland lying below the surface. When everted the vent presents to the surface many small tubules and the strongly diverted papillae. The vent of the female is a simple slit, smooth externally and usually surrounded by a light colored area.

It is possible to distinguish the sex in four-year-old specimens. A male only 142 mm long has the characteristic crescentic groove back of the vent and the paired papillae are present as short, blunt lobes.

Activities of the Breeding Season

Migration. In the fall, late September and October, the males search out the females in their retreats beneath rocks, old logs or water-soaked planks and hide with them for the mating period. The majority of males seem to be ready to mate when they find the females, for their testes are greatly enlarged, the cloacal glands much swollen and the vent protuberant and inflamed. The females, on the other hand, may or may not be ready to receive the attentions

of the male and the length of the period the sexes are together is apparently determined by the condition of the female.

Often a single pair occupies the retreat and in such instances the excavation may well serve the female throughout the year, including the nesting period. In other instances, however, a considerable number of individuals of both sexes will congregate beneath a single large rock or stone for the mating period and afterward separate, the females depositing their eggs in a nest of their own choosing, apart from the others. On October 14, 1932, in Salmon creek, Monroe county, N. Y., six females and two males were found together beneath a single large rock slab, several of the females each with a spermatophore in the vent. Another stone sheltered five females but no males, and a smaller stone, two males and one female. Altogether, on this date, 37 adult females and 23 adult males were found and five young of the year.

The wanderings of the males in search for mates and the congregation of individuals of both sexes in considerable numbers is not to be regarded as a definite migration, for some merely abandon their own hiding places for a time and after mating return to them.

There is a rather definite dispersal of the young of the year when they finally leave the nests but the process is long drawn out and is not to be regarded as a concerted migration. A few young may be found in nests even in late November but the majority will have become widely distributed. The young after leaving the nest gradually work their way out of the sections of the stream in which adults are found, and during the period of several years before reaching sexual maturity are likely to be found in deeper pools. In my experience, the sexually immature individuals, other than young of the year, are very seldom found on the nesting grounds or associated with adults.

Mating. Observations made by Paul A. Webb, of Meadville, Pa., and reported by Bishop (1926, p. 11) indicate that a kind of courtship may be involved in the mating activities. A pair was placed in a large aquarium and the male manifested considerable interest in the female, behaving somewhat after the manner of the male newt, *Triturus viridescens*. "The female received the attentions, held herself erect by supporting the body on the hind legs and tail and made no attempt to escape. The male swam and crawled around the female and frequently passed over the tail and between the legs. This performance was continued for a considerable period." At the time these observations were made no spermatophores were noted.

Kneeland, however, (1857, p. 154) reported the deposition of gelatinous masses, suggestive of spermatophores, by males retained in aquaria throughout the winter. My own observations supported those of Kneeland and the presence of the gelatinous masses in the vents of males taken in the fall was reported. These masses were not found to contain spermatozoa and thus direct evidence pointing toward the actual deposition of spermatophores was lacking. It was suggested, however, (Bishop, 1926, p. 12) that spermatophores were doubtless formed and subsequent study has shown this to be true.

The swollen and inflamed condition of the vent in breeding males is retained for several months and we have perhaps been in error in assuming that the mating season is strictly limited to a comparatively short period in the fall. In general this is probably true but exceptions may be noted. Thus, on April 18, 1932, three females and a male were found beneath a single stone in Salmon creek, Monroe county. The vent of the male was inflamed and everted and the cloacal glands as much enlarged as they normally are during the fall mating period. Males taken in Salmon creek, February 4, 1933, exhibited the same condition and suggest the possibility of a more extended mating season than that indicated by the discovery of spermatophores in the vents of females taken during October.

Spermatophores. The complete spermatophore of *Necturus* is known only from those deposited in aquaria following stimulation by injection of pituitary extract (Bishop, 1932, p. 1–3). Since the saclike terminal portion of the spermatophore, filled with sperm, has been recovered from females taken in the field, the time of insemination is well established. In Salmon creek, Monroe county, N. Y., females with sperm-masses were collected on October 18, 1930, and again on October 14, 1932. Complete spermatophores were deposited in aquaria in October 1931. Spermatophores deposited following stimulation by injection of pituitary extract may or may not be typical of the species. Those recovered consist of a gelatinous basal part supporting an apical, milky-white sperm mass, the whole surrounded by a thin layer of clear jelly. (Figure 5, *d*). The external coating of clear jelly is thin where it passes over the sperm mass and is drawn out at either end to form a slender string. These spermatophores lack a broad base for attachment and it is possible, though not likely, that direct transference to the female is the normal procedure.

Single spermatophores vary in length from 10 to 12 mm and in diameter, from 6 to 8 mm.

The nests of Necturus. Smith (1911, p. 191), studying *Necturus* in a lake habitat, found nests in water from three to five feet deep and from 50 to 100 feet from shore. The nests were excavations beneath large stones and the number of eggs present in a nest was determined in five cases as follows: 18, 61, 80, 84, 87, an average of 66. These numbers are much below the average of normal females I have studied in a stream habitat.

Eycleshymer (1906, p. 133) also studied *Necturus* in a lake habitat and wrote:

> The objects beneath which the eggs are most frequently found are clean logs or boards which lie partially imbedded in the sand. The writer has also found them beneath pieces of tin, canvas, and even an old hat.
>
> The depth of the water in which these nests are found is variable. The writer has found nests covered by only four inches of water, again a nest was found beneath a board at a depth of 10 feet, but these are unusual conditions. The majority of nests are found at a depth of from 2 to 4 feet. The nests are often found in close proximity to one another; and it is not at all exceptional to find several nests on a single board, frequently not more than a foot apart. In one instance ten nests were taken from a single board not more than ten feet long.

In a stream habitat, nests are found in water varying in depth from a few inches to two feet or more. Usually there is some evidence of an excavation beneath the shelter chosen and during the egg-laying season and period of incubation the female alone is found.

The nests are most frequently placed near the rifts, but not in the fastest water. It is useless to search beneath stones or rocks that lie in such a position that the current sweeps under them. Usually the support chosen is partially imbedded in the stream bottom with an opening on the side away from the direct current. This is obviously a provision to prevent the filling up of the excavation.

I have never discovered the nests of *Necturus* in very small streams. Where the species is most successful, judging by the numbers present, the streams are rather broad and shallow with stretches of bed rock and gravel alternating with deeper pools and riffles.

As noted above, Smith determined the number of eggs in five nests and found them varying from 18 to 87. In three stream nests in Woodcock creek, Pa., the eggs numbered respectively 87, 96 and 140, an average of about 107. Paul A. Webb counted the eggs in several nests and found them varying in number from 90 to 180, the higher number perhaps representing the complements of two females.

In one nest in Salmon creek, Monroe county, N. Y., the eggs numbered 125. Other nests from this locality contained respectively 48, 67, 82 and 103 eggs. Eycleshymer (1904, p. 230–40) recorded but 62 eggs in a nest.

It will be noted that the number of eggs recorded from nests in a lake habitat by Smith (average 66) and Eycleshymer (62) is very much below the average for nests in a stream habitat as determined by Webb and Bishop.

The egg-laying process. The eggs of *Necturus* are deposited on the lower surface of a support in water. To attach the eggs in this position the female turns herself back downward, brings the vent close to the support and fastens the eggs singly, shifting the body slightly after each egg is released to avoid accumulation at one point. Observations on egg laying were carried on in the laboratory where a large female, discovered in the act of beginning ovulation in the stream, continued the process over an extended period, depositing about a dozen eggs in the course of a day. Bishop, 1926, p. 15, wrote:

The eggs may be scattered over an area 12 inches or more in diameter or crowded together in a space only 6 or 8 inches wide. The eggs are deposited one at a time and are attached by a circular, disc-like expansion of the outer envelop, some 5 or 6 mm in diameter. There is a slight constriction below the attachment disc when the eggs hang in natural position, buoyed up by the water; but this lengthens to a slender stalk when the support to which the eggs are attached is lifted above the surface.

Development

The egg and its envelops. The egg of the mudpuppy, without its envelops, is a light yellow sphere five to six mm in diameter. It is without pigment and derives its color from the yolk. The envelops are disposed as follows: First, a thin, tough and elastic membrane inclosing a jellylike substance which may be slightly milky; second, a slightly thicker layer, clear and transparent; third, a thick, jellylike layer which is extremely elastic and forms the outer covering and the attachment stalk. When the egg itself has a diameter of five or six mm the innermost envelop will measure about seven mm in diameter, the middle envelop about eight mm, and the outermost 11 mm. As the eggs hang free in the water, they have a length of 14 to 16 mm.

Smith (1912, p. 79) gives the detailed structure of the envelops as follows:

There are three layers to the gelatinous envelop: (*a*) a comparatively thin but very dense inner layer, consisting of several lamellae; (*b*) a thicker median layer of moderate density, consisting of many lamellae; and (*c*) a very thick outer layer of homogeneous material, much less dense than either of the preceding. This outer layer is produced to form a stalk by which the capsule is attached to some solid support.

The lamellar structure noted by Smith is apparently not well developed in all envelops and is entirely lacking in some of my early embryo material preserved in formalin. The middle envelop as shown in the figure presented by Smith (1912, p. 80, fig. 4) is also much thicker and denser than in my specimens.

The incubation period. The first eggs of the season usually appear about June 1st in western New York and western Pennsylvania. If the season is early and the water warms sufficiently, the season may start a week or two earlier. Ordinarily, since a large proportion of the females deposit their eggs at approximately the same time, the period of deposition in any locality is comparatively short. With falling temperatures, it may be considerably extended. In 1925, when the first eggs of the season appeared on June 5th, the last freshly deposited eggs were found on June 11th.

The first appearance of eggs and the length of the incubation period in a number of localities are indicated below:

Locality	*Fresh Eggs*	*Hatched*	*Incubation Period*
Woodcock Creek, Crawford Co., Pa.	June 5, 1924	July 25, 1924	50 days
Woodcock Creek, Crawford Co., Pa.	June 5, 1925	July 13, 1925	38 days
Quaker Run, Catt. Co., N. Y.	June 1 (?), 1927	Aug. 2, 1927	63 (?) days
Salmon Creek, Mon. Co., N. Y.	May 28, 1929	July 24, 1929	57 days
Salmon Creek, Mon. Co., N. Y.	May 23, 1931	.....	.....
Salmon Creek, Mon. Co., N. Y.	May 21, 1932	.....	.....
Salmon Creek, Mon. Co., N. Y.	May 12, 1934	.....	.....

Eycleshymer (1906, p. 132) collected eggs in a lake habitat as early as May 3d and as late as June 5th, these dates probably marking the beginning and closing of early and late seasons.

The short incubation period of 38 days reported for Woodcock creek in Pennsylvania is to be accounted for by the shallowness of the water and consequent high temperatures attained early in the season. On June 5, 1925, the temperature near the surface varied

from 74 to 78 degrees F., while under ordinary stream conditions, at this season of the year, the water is usually much colder.

In general, it may be said that the period of incubation covers about two months.

The newly hatched larva. Larvae at hatching have an average length of about 22.5 mm. Twenty, picked at random from a lot collected in the field and preserved on the day of hatching, varied from 21 to 25 mm. The lot from which the measured specimens were taken furnished some 200 additional individuals having a length of about 22 mm.

Fig. 7 *Necturus maculosus maculosus*. Recently hatched larva, actual length, 23.3 mm. July 16, 1925. H. P. C., del.

Smith (1911, p. 195) recorded an average length of 18 mm. The difference between his measurements and mine was due, perhaps, to the premature escape of the embryos from envelops ruptured in removing the eggs from the surface to which they were attached.

At the time of hatching the larvae are provided with gills, each rachis supporting two rows of filaments, the terminal ones elongated and flattened. The toes of the front feet are short and pointed. The hind legs are relatively short and directed backward with the toes scarcely developed. The eyes are well pigmented and apparently functional. The mouth, lips, nostrils and gular fold are well formed. The yolk is present and colors the venter between the hind and fore

legs. The tail is provided with a broad keel above and below and comprises about four-elevenths of the total length. The dorsal keel proper originates at a point above the insertion of the hind legs and is continuous with a slightly raised ridge which runs along the mid-dorsal line of the back to a point above the fore legs.

The color pattern of the young mudpuppy is strikingly different from that of the adult. As Bishop, (1926, p. 21) described it:

A very narrow light line follows the sharp edge of the dorsal ridge. A strongly pigmented median dorsal band originates on the snout a little in front of the eyes and continues along the back and on the tail where it fades towards the tip. On the head it maintains a width about equal to the distance between the eyes but just behind the gills it narrows abruptly. The dark dorsal band is bordered on each side by a somewhat narrower yellow band which in this stage is free from dark pigment. These light bands originate opposite the base of the third gills and continue along the upper part of the sides and the basal third of the tail where they are usually lost in the general pigmentation of the upper tail fin. On the head the dark median area is bordered on either side by a short light bar which originates in front of the gills and passes to the upper margin of the eye. In some individuals it narrows above the eye and continues to the snout.

Below the lateral light bands are the conspicuous dark stripes of the sides, extending from the gills to the tip of the tail. They are continued on the head in bands that curve downward in front of the gills, pass through the eyes and run together on the snout. Below the dark bands the pigment gradually fades out as it spreads over the yolk-distended abdomen, the upper surfaces of the limbs and the gill branches. In some individuals there are a number of small, rounded light spots quite regularly spaced throughout the length of the lateral dark band.

Development to maturity. *Necturus,* in most of its essential features, retains its larval character throughout life. There is a stage in the development of the young, however, which is perhaps reminiscent of a period when, in ontogeny, transformation was the normal procedure. During the three or four weeks following hatching the gills develop rapidly and there is a noticeable increase in the size and length of the gill filaments. Following this period of rapid growth they begin to shorten and at about the age of seven weeks the filaments are again reduced to the comblike condition characteristic of the recently hatched larva. The rapid growth and subsequent reduction of the gills is strongly suggestive of the phases through which the larvae of the true salamanders pass in their development and metamorphosis.

In an earlier paper (Bishop, 1926) measurements were presented to indicate the annual growth of *Necturus* to sexual maturity. The figures there given are here summarized briefly:

First year. Forty-four specimens collected between August 20 and 30, 1925, approximately 13 months after hatching, varied in length from 49 to 64 mm and averaged 56.1 mm. Thirty-nine of the 44 specimens varied in length only 11.5 mm or from 49 to 60.5 mm and averaged 55.2 mm, a figure which may be taken as fairly representing normal growth.

At the age of one year the early larval pattern is still well developed but the median dorsal band instead of being dark gray or almost black is definitely yellowish brown. In the majority of specimens the dorsal band ends abruptly at the origin of the dorsal tail keel; in others it continues to color the fin to the extremity of the tail. The lateral light bands are a deep dull yellow. They are prominent on the head back of the eyes and in some instances extend to the nostrils in front. They persist along the trunk and in many specimens unite at the anterior end of the dorsal tail fin and continue to the tip. Where this occurs the dorsal fin is lacking in dark pigment. The dark lateral bands continue, as in younger larvae, from the snout through the eyes to the tip of the tail. The lower sides may be definitely spotted or almost uniformly colored. In the majority of specimens the lips are dusky at the margins and there are intrusions of pigment on the sides of the head below the eyes.

Second year. Seventeen specimens regarded as falling within the two-year class varied in length from 70 to 95 mm with an average of 83.4 mm. In seven of the specimens the median dorsal band persisted as a rather narrow stripe, distinct and bordered by dull yellow. In the remaining specimens the band was wider, dull yellow mottled with dark brown, the dark predominating. The yellow bands bordering the median stripe are dulled by scattered chromatophores of darker pigment. In a few instances they are well marked from snout to the tip of the tail. The dark lateral bands remain constant in all specimens, while in three individuals rounded dark spots are scattered over the back. The venter in the majority of the specimens is very lightly pigmented.

Third year. The average length of 27 specimens which, from their size and conformation, were judged to be in their third year, is 113 mm. The extremes of 97 and 128 mm show a variation in length of 31 mm.

In this series the median dorsal band persists as a narrow uninterrupted stripe in only five specimens. In a single specimen the lateral light bands have entirely disappeared; in the remaining specimens the dorsal area is dusky brown with a broken and irregular median band indistinctly developed. The light bands of the sides are more dorsal in position than in the younger specimens, due to the development of, and change in the shape of the trunk. The dark lateral bands are still in evidence though somewhat broken and mottled. The lower sides are strongly spotted and the venter may be lightly pigmented, somewhat spotted, or free from pigment.

Fourth year. Thirty-one specimens vary in length from 130 to 167 mm with an average of 148.7 mm.

During the fourth year the majority of specimens attain a color pattern essentially like that of the sexually mature. The color above is usually chocolate brown with a few scattered, rounded, bluish black spots. In a few specimens the light lateral stripes are indicated by dull broken bands. The dark lateral bands still persist in the majority of specimens, most in evidence on the sides of the head and tail. The variation in the pigmentation of the venter in this series is that commonly observed in any series of adults.

Fifth year. In a series of 66 specimens the variation in length is from 169 to 210 mm, the average 187 mm.

The adult color pattern is developed in the majority of specimens in this age group. A few individuals may still retain the dark bands of the sides, best developed on the head and tail.

It is probable that some specimens within the size limits indicated above are in their sixth year, but in general six-year-old specimens average considerably larger and have attained sexual maturity. Individuals may reach maturity at a length of only 200 mm.

Since the mating season is in the fall and egg laying follows in the spring, the males in any series of the same age must mature the sexual elements several months before the female or hold over another year before mating. I believe the males ordinarily mature first.

Habits

General. The mudpuppy is aquatic and only rarely found out of water. It is essentially nocturnal in clear streams and lakes but in muddy streams and weedfilled waters of both streams and lakes it is more or less active throughout the day. It is found at all seasons of the year and has been observed swimming beneath the ice in the coldest winters (Morse, 1904, p. 107).

The usual method of progression is a slow walk or crawl over the bottom, the diagonally opposite legs moving together. If frightened it is capable of swimming rapidly, the legs held to the sides and the body and broad tail thrown into lateral undulations.

. The secretive character of the animal is constantly exhibited by specimens in captivity. They persistently seek to hide beneath anything available in the aquarium and where a number of individuals are confined together without shelter they burrow under one another. When disturbed in their hiding places in streams or lakes they immediately seek shelter, often burrowing beneath a stone that covers only their heads. If placed in an aquarium lighted at one end, they seek the more shaded parts.

In poorly aërated water or in water warmer than that to which the animals are accustomed, the gills are kept in constant motion and at intervals they rise to the surface, gulp in a mouthful of air and again sink to the bottom. In clear, cold, well-aërated water the gills are usually held motionless at the sides of the neck. Under such conditions, the blood supply of the gills is restricted, the gills shrink to half their length and take on a dull red color.

In addition to the bushy gills, functional lungs are present and some interchange of gases takes place directly through the skin.

Food. The natural food of *Necturus,* as determined by examination of the stomach contents, consists of fish, fish eggs, crayfish, aquatic insects and their larvae and worms. Small mollusks are also said to be taken (Hay, 1892, p. 419). Surface (1913, p. 81) examined 20 specimens, 18 of which contained food, including earthworms, sowbugs, spiders, crayfish and insects. Thirty-three adults from lakes near Madison, Wis., were examined by Pearse (1921) and the stomach contents revealed the items here listed in the order of their importance, the figures indicating per cent by volume: "Crayfishes 38.1; plants 17.9; insect larvae 17.2; fish 12.5; snails 7.2; sticks 4.4; leeches 2; cladocerans 1; sedimentary debris 0.3; ostracods, trace; amphipods, trace." Hamilton (1932, p. 83) examined nearly 500 stomachs of which 340 contained food. His complete record follows: "The following numbers indicate percentage by bulk: crustaceans, 32.7; insects, 30.1; fish, 13.2; annelids, 11; mollusks, 5.2; amphibians, 4.1; inorganic, 3.3; and a trace of vegetation in several stomachs. Since the individuals studied have been taken at various times of the year, including winter, the results indicate a fair index of the choice exercised by this animal. Among Crustacea, *Cambarus* is most frequently eaten. Scuds (*Gammarus,*

Hyallela) were found in many stomachs. Often only four or five of these small malacostracans were in an individual, indicating perhaps that the small forms are pursued separately. Aquatic forms dominated among the insects. Burrowing mayfly nymphs, *Hexagenia,* and caddis fly larvae, *Limnophilus,* the latter usually pulled from the cases, as well as burrowing forms of Odonata, large numbers of chironomid larvae, the young of such beetles as *Dytiscus* and *Haliplus,* made up the majority of insects consumed. A few sialids and tipulid larvae, with an occasional *Belostoma,* were eaten. Fish are eaten avidly. *Necturus* has a great fondness for sculpins. Dr William Senning has told the writer of finding mudpuppies gorged with these fish. The salamander will resort to the mouths of small streams emptying into the lake where the sculpins are secured. Small minnows, *Hybopsis* and *Hyborrhynchus,* (sic) are occasionally devoured, but they are apparently too speedy for *Necturus* to catch often. An individual taken in swift water of the inlet to Cayuga lake had eaten a blacknosed dace, according to Doctor Senning:

Annelids eaten were principally large earthworms, but smaller aquatic oligochaetes and leeches were found in many stomachs. Snails, *Limnaea* and *Planorbis,* are frequently taken. One individual had overcome a newt, while several had fed upon *Desmognathus,* probably taken when searching for food among the swift waters of incoming streams. Here they likewise encounter *Eurycea b. bislineata,* for two individuals contained this species. Their own cast skins had been eaten by three, while what appears to be eggs of *Necturus* were swallowed by two. A trace of algae and a not inconsiderable quantity of small flat stones were found in several stomachs. It seems unlikely that the stones were taken in accidentally, for some specimens had nothing but these in their stomachs.

Habitat

The mudpuppy is found under the most diverse conditions. It is abundant in the clear waters of the Great Lakes and tributary streams, in at least two of the narrow, deep and cold Finger Lakes of central New York and in muddy and weed-choked streams, backwaters and bayous. Even polluted canals, stagnant reservoirs and drainage ditches will often harbor them by the hundred. In clear, shallow, rapid streams with rocky bottoms they are easiest to discover but are often present in numbers in deep, slow streams with mud banks and bottoms. They are common in the St Lawrence, Hudson and Mohawk rivers, in the canals of the State and Lake Champlain.

In broad, shallow streams that become warm early in the season the adults are most abundant in the well-aërated areas near the rifts and ripples. These are the nesting sites. The immatures in the same stream seem to leave these areas largely to the sexually mature and take up their residence in the deeper pools. There is thus some segregation in the stream habitat.

In Cayuga lake, the mudpuppy occurs in abundance in the shallows at the south end and works its way up the Inlet and into the mouths of the tributary streams. A few may be found in deeper parts. Sodus Bay is warm, shallow, weedy and mud-bottomed. Here the mudpuppy is rather generally distributed and is frequently taken by fishermen using worms or live bait. The Clyde river is uniformly muddy throughout its length, with mud banks and bottoms and scarcely any gravel stretches except near headwaters; yet the mudpuppy persists in numbers.

The ability the mudpuppy has to exist in waters of such diverse character probably accounts for its wide distribution. Because of its wide distribution it encounters, in its various habitats, many types of food organisms and competes for these with an enormous number of other animals. In the streams it is in competition with the common creek fishes such as suckers, darters, bullheads, the basses, pickerels, horned dace and many other minnows.

In the bays and lakes of New York it takes the same type of food that is utilized by the game fishes and must make serious inroads on the available supply.

Remarks

The first reference to the species in New York waters seems to be that of Schneider (1799) who described the animal from a specimen said to have been taken in Lake Champlain. Other early records from Lake Champlain are those of Barnes (1826, 1828). Barnes (1826) also mentions a specimen taken in the Erie canal at the Lake Erie entrance in 1825, the year the canal was opened for traffic. Mitchill (1822) records the species, under the name *Proteus,* from Black Rock, now a part of Buffalo. Mitchill pointed to the correct relationships of the species when he allied it to the *Proteus* of Europe but later (1824) he unfortunately confused it with *Cryptobranchus.* The first mention of the mudpuppy from the Hudson river I have found is that of Gebhard (1856). Smith (1882) and Marshall (1892) subsequently reported specimens from the Hudson, each apparently under the impression that he was the first to make the discovery.

The trematode, *Sphyranura osleri,* is often found attached to the surface of the skin.

Range

The Mississippi river system from the Arkansas river northward, the Great Lakes, St Lawrence river and tributaries, Lake Champlain, Mohawk river and Barge canal, middle Hudson (probably by way of the old Erie canal), Susquehanna river, Delaware river (perhaps by way of the old D. and H. canal); Connecticut and Farmington rivers (introduced).

In the lower courses of certain rivers in North and South Carolina, and Georgia there is a dwarf form of the mudpuppy which has been described by Brimley (1924) as *Necturus maculosus lewisi.*

Fig. 8 New York localities for *Necturus maculosus maculosus.*

Distribution in New York

General. In general terms, the distribution in New York is essentially as follows: Lake Erie and Ontario and their tributaries; Allegheny river and tributaries; Chautauqua lake, Seneca lake, Cayuga lake and tributaries; Oneida lake and tributaries; St Lawrence river, Lake Champlain, Erie (now Barge) canal, Mohawk river, Hudson river, south, at least to Poughkeepsie.

Specific records. ALBANY: *Albany,* Hudson river, May 1855 (Gebhard, 1856); 1873 (Rep't State Mus., 1875); (Marshall, 1892, 1894); trib. of Hudson, 1875 (Rep't State Mus., 1878); Albany water supply, 1887 (Rep't State Mus., 1888); (Bishop, 1923); *Kenwood,* 1899 (Rep't State Mus., 1901); (Bishop, 1923); *Normanskill,* July 1, 1924, 1 ad. ALLEGANY: *Ceres,* Oswayo creek, Aug. 30, 1926, 3 ads. (S. C. B. and W. P. Alexander). CATTARAUGUS: *Allegany State Park,* Allegheny river at mouth of Wolf run, Nov. 23, 1930, 2 larvae, 38 and 40 mm; Sept. 21, 1931, 1 ad.; Oct. 10, 1931, 1 yg., 4 in.; Oct. 22, 1932, 1 ad.; Oct. 20, 1934, 4 spec., U.R. No. 3451; Oct. 19, 1935, 1–6 in.; May 7, 1938, 1 juv.; Oct. 15, 1938 sev. ads.; *Quaker run, Indian res.,* Aug. 23, 1926, 5 females with yg. in nests, 1♂, N. Y. S. M. No. 3077–8 (Bishop, 1927); Aug. 1, 1927, sev.♀ with yg. in nests (Coker and Alexander); Aug. 2, 1927, 2♀ in nests with yg. at point of hatching (Coker and Alexander); Oct. 22, 1932, 1 ad.; July 1937, 31 ads., 900 eggs, Aug. 20, 1937, 1 ad. U. R. No. 4170; May 7, 1938, 1–5 in. juv.; *Wolf run, Indian res.,* Aug. 15, 1923, 1 ad., N. Y. S. M. No. 3324 (W. P. Alexander); Aug. 31, 1926, 1♀, N. Y. S. M. No. 3282 (Bishop, 1927); *Ischua,* Ischua creek, Oct. 15, 1933, 4 ads. (S. C. B., R. Odell and C. R. Crosby); *Salamanca,* Aug. 1926, C. M. No. 4053. (W.P.A.) CHAUTAUQUA: *Bemis Point, Chautauqua lake,* June 16, 1937, ads. and eggs. CLINTON: *Plattsburg barracks,* U. S. N. M. No. 14737 (W. O. Owen); mouth of *Saranac river* (Hudson). DUTCHESS: *Poughkeepsie* (Smith, 1882). ERIE: *Black Rock,* (Mitchill, 1822); Lake Erie entrance of *Erie canal* (Barnes, 1826). ESSEX: *Lake George outlet* (DeKay, 1842); *Ticonderoga,* Jan. 26, 1928, 1 ad., thru ice (Abare). JEFFERSON: *Somerville,* M. C. Z. No. 190, 166, 1201 (Hough). MONROE: *Black creek,* 1930, 1 ad.; *Braddocks bay,* May 9, 1932, 1♀ (R. Redman); *Genesee river,* 1930, 1 ad.; at *South Park,* Mar. 25, 1939, 1 ad. (Cooper); *Irondequoit bay* and *creek* (Wright and Moesel, 1919); Dec. 6, 1934, 1 ad. ♀; *Larkin creek* (E. A. Maynard); *Long pond inlet,* May 5, 1931, 1 juv. (E. A. Maynard); *Rochester,* M. C. Z. No. 313, 3 spec. (Dunn, 1918); *Salmon creek* (Wright and Moesel, 1919); Jan. 6, 1933, 3 ads., 1 larva; at Burritt road, May 28, 1929, unsegmented eggs (E. Hilfiker); May 6, 1930, 20 spec., both sexes; Oct. 3, 1930, 2 ads., U. R. No. 1177–78; Oct. 18, 1930, 3 ad. females; Oct. 7, 1931, 4♂ 9♀; Spring 1932, U. R. No. 2672; Apr. 18, 1932, 1♂ 3♀; May 1, 1932, 2♀; May 21, 1932, 1♀, and eggs in 2 nests; Sept. 11, 1932, 12 spec. (K. Lagler); Oct. 10, 1932, 4♂ 7♀; Oct. 14, 1932, 23♂, 37♀, 5 larvae (S. C. B. and M. Shurr); Oct. 9, 1933, 1 larva; Feb. 4, 1933, 3♂ 4♀ (S. C. B. and H. Chrisp); Oct. 2, 1933; Apr. 19, 1935, 3♂, 2♀; May 12, 1938, ad. and eggs (Maynard); bet. Hilton and Parma corners, Nov. 1, 1928, 1 ad.; May 29, 1929, fresh eggs, U. R. No. 770; June 1, 1929, 3 ads.; near Parma, May 23, 1931, fresh eggs (E. Hilfiker); May 12, 1934, ad. ♀ and eggs (E. A. Maynard); *Sandy creek* (Wright and Moesel, 1919); near Hamlin, May 30, 1932, ♂ ♀ and eggs; near N. Hamlin, May 25, 1932, ♀ and eggs; May 14, 1937, sev. ads. ONONDAGA: *Onondaga creek* (Britcher, 1903); *Syracuse,* Erie canal (Britcher, 1903). ORLEANS: Orleans Co., 1879, 1 ad., U. S. N. M. No. 570, 396 (J. Hurter). OSWEGO: *Oneida lake,* Willow Point, July 17, 1916, R. S. No. 554 (P. S. Welch). RENSSELAER: *Lansingburg* (Marshall, 1893); *Troy,* Hudson river, 1871 (Rep't State Mus., 1873. ST LAWRENCE: *Black lake* 1878, M. C. Z. No. 1772 (S. Garman); *Madrid,* Grass river, U. S. N. M. No. 7038 (Yarrow, 1882; Cope, 1889). SARATOGA: *Crescent,* Mohawk river, 1869 (Rep't State Cab., 1873; Bishop, 1923). SENECA: *Seneca lake,* 5 mi. south of Geneva (A. Sterling). TOMPKINS: *Cayuga lake,* Sept. 19, 1876, Apr. 17, 1882, Sept. 1882, Feb. 20, 1884, Apr. 7, 1884, Nov. 19, 1884, Dec. 8, 1884, Dec. 10, 1884, Mar. 21, 1910 (C. U.); June 12, 1917, 1 ad. (J. D. Corrington); M. C. Z. No. 1861, 17 spec. (Wilder), No. 1282, ads., No. 1713, 2 spec., No. 1371, 2 spec. (Dunn 1918); M. C. Z. No. 2010, 17 spec. (Wilder); Apr. 3, 1932, ads. abdt. (W. J. Hamilton); *Crowbar point,* Cayuga lake, Feb. 27, 1924 (W. J. Hamilton); Mar. 14, 1930 (W. J. Hamilton); *Ithaca,* Feb. 3, 1910, 8 spec., A. M. N. H. No. 1853–60; U. S. N. M. No. 17925–6, 19064, 25,144 (W. P. Hay); (Fowler and Dunn, 1917); Fall creek, Mar. 1910 (C. U.); May 7, 1924, 1 ad. (Harper); Inlet, Mar. 28, 1922 (C. U.). ULSTER: *Kingston,* Hudson river (W. J. S.). WAYNE: *Clyde,* Clyde river (Wright and Moesel, 1919; Bishop, 1926); *Sodus ditch; Sodus bay.*

Records too indefinite to be placed under counties: *Allegheny river* (Baird, 1850); *Cayuga lake* (Hamilton 1932); *Lake Champlain* (Schneider, 1799; Harlan, 1825; Barnes, 1826, 1828; DeKay, 1842; Holbrook, 1842; Baird, 1850; Waite, 1907); M. C. Z. No. 276, 2 spec., No. 1061, 2 spec., No. 1844, 1 skull (Dunn, 1918); *Lake Erie* (Mitchill, 1822; DeKay, 1842; Waite, 1907); *Genesee river* (25th Rep't State Mus., 1873); *Oneida lake,* Mar. 1929, 1♀, albino (J. D. Corrington, 1931); *Seneca lake* (DeKay, 1842); 3 ads. (Hobart College col.); *Western New York* (DeKay, 1842; Allen, 1868).

Condensed Bibliography

Life history and habits. Bishop 1926, p. 5–60 (*Necturus maculosus*); Bishop 1927, p. 30–34 (*Necturus maculosus maculosus*); Bishop 1932, p. 1–3 (*Necturus maculosus*); Eycleshymer 1906, p. 123–36; Hamilton 1932, p. 85–86; Hay 1892, p. 418–20 (*Necturus maculatus*); Morse 1900, p. 106; Pearse 1921, p. 1 (*Necturus maculosus*); Smith 1911*a*, p. 191–200.

Distribution in New York. Allen 1869, p. 202 (*Menobranchus lateralis*); Baird 1850, p. 291 (*Necturus lateralis, Necturus maculatus*); Barnes 1826, p. 267 (*Proteus lateralis*); Barnes 1827, p. 66–68 (*Proteus maculosus*); Bishop 1923, p. 64 (*Necturus maculosus*); Bishop 1926, p. 5–60; Bishop 1927, p. 30 (*Necturus maculosus maculosus*); Britcher 1903, p. 120 (*Necturus maculatus*); Cope 1889, p. 23; Corrington 1931, p. 83 (*Necturus maculosus*); DeKay 1842, p. 87 (*Menobranchus lateralis*); Dunn 1918, p. 445 (*Necturus maculosus*); Eckel and Paulmier 1902, p. 397 (*Necturus maculatus*); Fowler and Dunn 1917, p. 7 (*Necturus maculosus*); Gebhard 1856, p. 16 (*Menobranchus lateralis*); Hamilton 1932 p. 83–86 (*Necturus maculosus*); Holbrook, 1842, p. 111 (*Menobranchus maculatus,* p. 115 *Menobranchus lateralis*); Marshall 1892, p. 779 (*Necturus maculatus*); Marshall 1894, p. 33; Mitchill 1822, p. 181 (*Proteus*); Mitchill 1824, p. 63; Reed and Wright 1909, p. 402 (*Necturus maculosus*); Schneider 1799, p. 50; Smith 1882, p. 714 (*Menobranchus lateralis*); Wright and Moesel 1919, p. 63 (*Necturus maculosus*); 23d Ann. Rep't State Cab. Nat. Hist., 1873, p. 21 (*Menobranchus lateralis*); 25th Ann. Rep't State Cab. Nat. Hist., 1873*a*, p. 15; 25th Ann. Rep't State Cab. Nat. Hist., 1875, p. 23; 29th Ann. Rep't State Cab. Nat. Hist., 1878, p. 20; 41st Ann. Rep't State Cab. Nat. Hist., 1888, p. 29; 46th Ann. Rep't N. Y. State Mus., 1893, p. 22 (*Necturus maculatus*); 53d Ann. Rep't N. Y. State Mus., 1901, p. r. 169.

CRYPTOBRANCHUS ALLEGANIENSIS (Daudin)

(*Salamandra alleganiensis,* Hist. Nat. Rep't, 1803, 8: 231)

Hellbender, Giant Salamander, "Alligator"

Figures *2b, 4b,* 9–13

The hellbender is our largest salamander and is exceeded in size only by its close relative, the giant salamander of China and Japan and by *Amphiuma* of our Southern States.

Description

Size. The average length of 15 mature specimens of both sexes from the Allegheny river and its tributaries in western New York and Pennsylvania is 453.8 mm (17⅞ inches). These measurements are based on specimens taken on the breeding grounds during the egg-laying season. A large series taken at other seasons of the year give an average of about 16 inches. Thirteen sexually mature males

from the Allegheny river average 435.5 mm (17 3/16 inches), and vary from 295 mm (11⅝ inches) to 560 mm (22 inches). The largest specimen measured, a female, was exactly 597 mm (23½ inches). The largest individual of which I have record was 686 mm (27 inches) long. This was taken a few years ago in French creek, a tributary of the Allegheny, in Crawford county, Pennsylvania, by Paul A. Webb of Meadeville, Pa.

In the male the tail comprises from 30.5 to 38.9 per cent of the total length and is relatively longer in the smaller specimens than in those 15 inches or more in length. In the few females I have measured, the tail comprises about one-third of the total length.

Form. The hellbender is a great, flat, flabby creature with fleshy folds along the sides of the body and on the hind margins of the legs. Dorsally there is an impressed median line, most conspicuous on the anterior half of the body. The costal grooves are inconspicuous on the sides or lost entirely in the general wrinkled condition of the skin. In preserved specimens they may sometimes be distinguished on the lower sides and venter. The gular fold is reduced to a transverse wrinkle or lacking. The head is very broad and flat, widest at a point just back of the eyes then broadly rounding to the truncated snout. The small nostrils are placed at the angles of the snout. The eyes are very small, only 5 mm in diameter in a specimen 550 mm (21⅝ inches) long. The mouth is large and extends on the sides of the head to a point well back of the eyes. The tongue is large and fleshy and fills the floor of the mouth. The teeth are in two arched series, those of the maxillary extending to the angle of the jaws. The vomerine series is shorter, bow-shaped and limited on either side by the inner nares. The upper margin of the lower jaw is provided with a fleshy fold which extends from the angle of the jaw half way to the mid-line of the chin.

The fleshy body folds originate on the sides of the head, pass above the fore legs and, continuing along the sides and above the hind legs, extend a short distance on the sides of the tail.

The throat is marked with longitudinal wrinkles which converge on the chin. The gill slits are normally reduced to a single pair; rarely one or the other is closed. The openings are guarded externally by narrow vertical lips and are further protected by heavy folds of the skin which extend obliquely from the sides of the throat to the lateral folds of the neck.

The legs are relatively short and stout, the hind somewhat better developed than the fore. The toes are 5-4, flattened and rounded at the tips. Those of the hind feet are somewhat webbed at base

Fig. 9 *Cryptobranchus alleganiensis.* Adult, French creek, Saegertown, Pa. June 23, 1924. Actual length 22 inches.

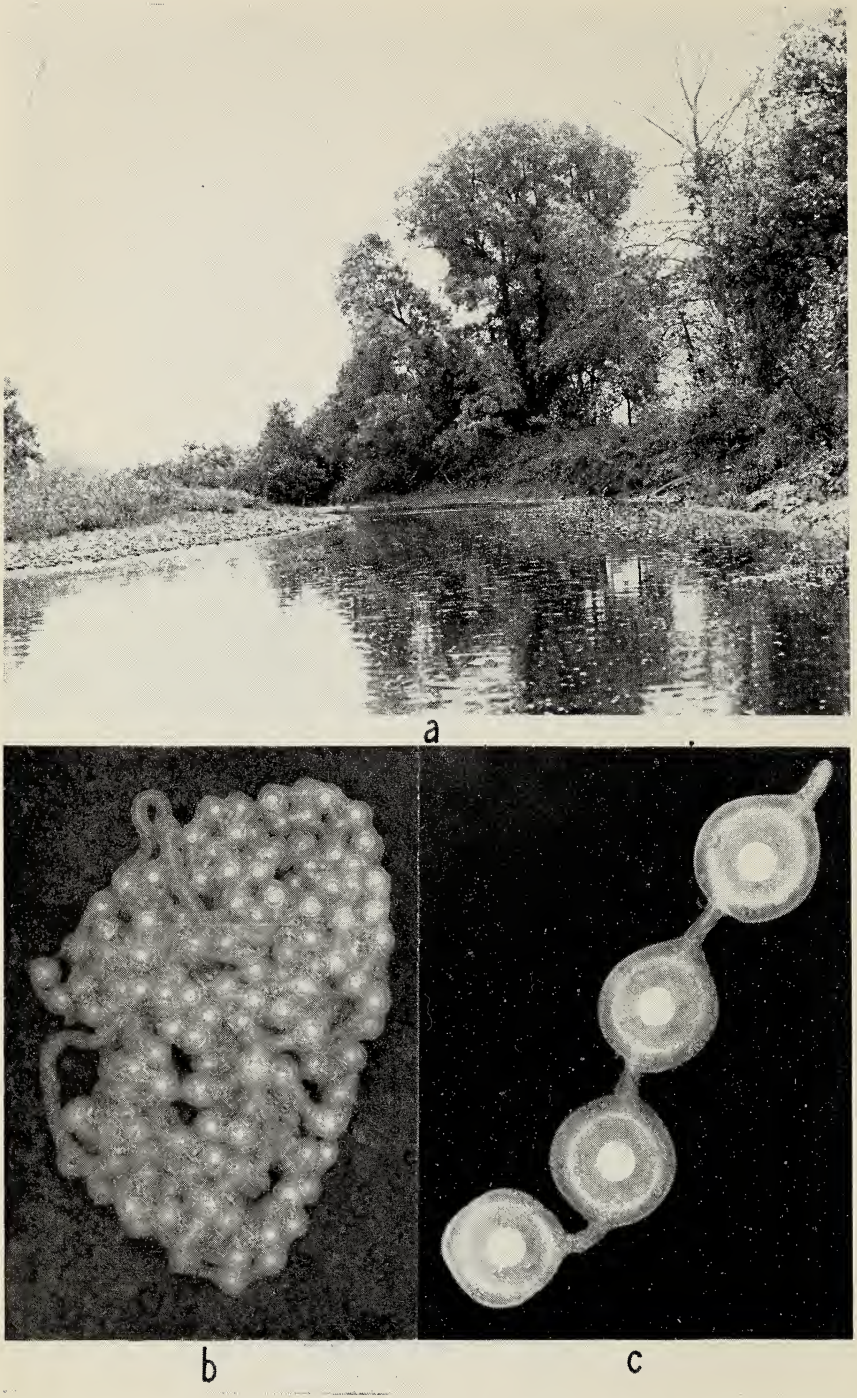


Fig. 10 a. Woodcock creek, Saegertown, Pa., habitat of *Cryptobranchus alleganiensis* and *Necturus maculosus*. b. Egg complement of *Cryptobranchus alleganiensis* removed from nest to shallow water. Sept. 3, 1925. c. Portion of egg-string of *Cryptobranchus*, about natural size.

and with free fleshy margins. The fifth toe of the hind foot is the shortest; others in order of length 1-2-4-3. The toes of the front feet are 4-1-2-3.

The tail is very strongly compressed and provided above with a wide thin keel which extends forward to a point a short distance in front of the hind legs. The lower margin is thicker and much broadened in front of the vent.

Color. The adults vary from light yellowish brown through dull brick red to almost black, but the majority of specimens are dull brown. The color is by no means uniform in the same individual at all times. The general ground color is broken by light or dark spots of irregular shape. The dark spots may be large or small, rounded or irregular, and widely scattered. A very large specimen was light yellowish brown, mottled above with darker brown and in the head region with a distinct greenish cast. Another large specimen was very dark brown with lighter yellowish spots at intervals along the lateral folds, scattered over the back and on the ends of the toes. Below, the color was almost uniform dark brown except for light areas on the throat, in front of the vent and a few small scattered spots on the belly. Some individuals, both young and adult, are light brown with large dark spots, irregular in shape and distribution. The belly in these strongly mottled specimens is often free from conspicuous spots and lighter than the back. Small specimens are usually more strongly spotted than adults. Some individuals when captured are bright rust-brown with prominent black spots but may rapidly assume more somber tones of dark brown.

Sexual differences. The sexes are essentially alike in color. The males, however, are often broader and heavier than females of the same length. The measurements of a pair taken September 1, 1926, at the mouth of Wolf run in the Allegheny river, N. Y., are here given:

	TOTAL LENGTH	TAIL LENGTH	TAIL WIDTH	HEAD GREATEST WIDTH	HIND LEG LENGTH
♂	554 mm.	192 mm	85 mm	96 mm	70 mm
♀	550 mm.	190 mm	65 mm	80 mm	67 mm

In the breeding season, the vent of the male is surrounded by a broad, swollen ridge, the enlarged cloacal gland. The vent itself is a simple longitudinal slit surrounded by a few small, round, papillae.

Activities of the Breeding Season

Mating. The mating season in northwestern Pennsylvania and southwestern New York begins about the last of August. According to Smith (1907, p. 19), with the beginning of the breeding season, a marked change takes place in the behavior of the animals in their natural environment; they no longer remain secluded in hiding places under rocks, but come out boldly by day, sometimes congregating in droves of from six to 12, showing a social instinct quite lacking during the summer. As a rule they roam restlessly about, poking their noses under crevices under rocks, as if exploring; sometimes, however, they lie quietly in the open. Several times they were observed to pile up in crevices between rocks, two or three lying alongside each other, or two or more at a time trying to force their way into the same crevice; this, however, may have been merely incidental to the favorable locality.

The activities reported above apparently precede the actual mating as a kind of nuptial congress, as sometimes takes place with such species as *Ambystoma maculatum*. Its apparent purpose is to stimulate the sexes to the point of mating. In my experience, the males at the time of mating are found occupying excavated cavities beneath flat rocks on the stream bottoms and the females are present in the nests only while engaged in egg laying.

On the breeding grounds, the males are either actually more abundant than the females, or so much more in evidence that they seem to outnumber them. Smith (1912, p. 69), in his discussion of the relative abundance of the sexes, found the proportion of females to be about one to two or one to three.

The males frequently lie in the nests with their heads at the entrance waiting the appearance of females with ripe eggs. Spent females and males are driven away if possible, the guardian male assuming full responsibility for the protection of the eggs until they have hatched.

Fertilization. Fertilization in *Cryptobranchus* is external, the exception among American salamanders, so far as known. Smith (1907*a*, p. 21), who observed the deposition of the eggs and their fertilization, reports:

The male moves to a position alongside and sometimes slightly above the female and overlying the eggs, or sometimes beside them. In this position, he makes swaying lateral and vertical movements of the posterior end of the body, raising and lowering it with his hind legs, much like a male *Triton viridescens* depositing a spermatophore, except that in the case of *Cryptobranchus* the motion is less violent.

The movements also resemble those of the female preliminary to spawning. While executing these movements the male extrudes from his cloaca a snowy-white ropy or cloudy mass which consists of seminal fluid mixed with the secretions of the cloacal glands. On one occasion the deposit occurred in ropy chunks about 4 mm in diameter and 2 or 3 cm long.

While the bulk of the eggs are being laid the female lies quietly on the bottom.

The egg-laying process. Egg laying under natural conditions takes place in the nest where the process can not be readily observed. Smith (1912, p. 73), who observed the egg laying on several occasions in creek aquariums, writes as follows:

Egg laying begins slowly, a short string of eggs sometimes protruding from the cloaca for several hours before spawning begins in earnest. In the natural habitat, such short strings of eggs are often found in the open. Later, two long strings of eggs proceed slowly from the cloaca, one from each uterus; the majority of the eggs are then deposited more rapidly, in multiple strands, the process requiring less than five minutes. When egg laying is completed, the strings are usually twisted together in a single tangled mass.

The nests of Cryptobranchus. The nests of *Cryptobranchus* are excavations beneath large flat rocks partially embedded in the stream bottom and with an entrance out of the direct current and usually on the downstream side. Advantage may be taken of a natural cavity but in every instance where I have examined a nest there was evidence that a considerable amount of material had been removed.

The following description of a nest and its occupants is taken without change from my field notes:

Woodcock creek, Pa., Sept. 4, 1925. A large, flat stone 36x33 inches and eight inches thick served as the shelter to the nest. When the stone was tipped on its edge, the eggs were exposed in a shallow excavation. The mass covered an area 13x14 inches and the eggs were heaped up so that those at the highest point of the mass were only nine inches below the surface of the water. When the rock was turned, two males were discovered, one 12¾ inches long, the other 16½ inches long. There was evidence of a struggle for the possession of the nest in the number of isolated eggs scattered at the entrance of the burrow leading to the nest cavity. A small *Necturus* was also found beneath the rock. When the water cleared, a third male *Cryptobranchus* of great size (22 inches long) was found as the actual guardian of the nest. It lay hidden beneath the mass of eggs. At times the head appeared from beneath the eggs or the tail was exposed as it moved from side to side. This animal was constantly alert, its head appearing first on one side of

the mass only to be withdrawn and suddenly thrust out on the opposite side. The egg mass was kept in motion by the movements of the male which, at times, appeared to be made deliberately for the purpose of aërating them. The body was arched and swayed from side to side and the eggs lifted and fell in response to the movements. While attempting to photograph the eggs, a fourth male, 16½ inches long appeared and attempted to enter the nest. For fear that it was likely to be the cause of considerable disturbance, this male was removed from the nest and tossed about 20 feet upstream. In less than ten minutes it had made its way back again, entered the nest and crawled beneath the eggs. It made its exit with great celerity, the guardian male lunging after it viciously. The actual size of the excavation was revealed when the eggs were removed. It measured 18x15 inches and the bottom of the nest was 15 inches below the surface of the water. The two smaller males were examined to ascertain whether or not they had been eating eggs, but the stomachs were empty. The smaller of these two was battle-scarred and bleeding from tooth cuts on the back near the hind legs and, when removed from the water, milt oozed from the vent. The guardian male resented the intrusion of the hand or stick thrust into the nest. The nest contained a total of 1946 eggs.

Since the male alone is responsible for the care of the eggs and accepts a number of females one after another, it is reasonable to suppose the excavation is prepared by the male in advance of the nesting season and is, presumably, occupied in successive years.

The egg mass. The egg mass is composed of the twisted strings of eggs deposited in a heap in the bottom of the excavation. The eggs are a little heavier than water and sink slowly when brought to the surface and released. The bottom of the nest excavation is saucer-shaped and tends to keep the eggs concentrated so that they cover the male and may be aërated by his movements beneath or among them.

The general color of the egg mass is dull yellow in clear water but the yellow is largely obscured when silt accumulates on the gelatinous envelops.

The eggs in two nests numbered respectively 319 and 334. These, presumably, were the complements of single females. A mature female contained a total of 317 eggs, 144 in one ovary and 173 in the other. Smith (1907*a*, p. 16) counted the eggs in the single uterus of a female of average size and found them to number 220; in another female of the same size he found 225. This gives a total of about 450 eggs. Since several females often deposit their eggs in the same nest, as many as two thousand may be present in a mass. As noted above, 1946 eggs were taken from a single nest, probably the complements of five or six females.

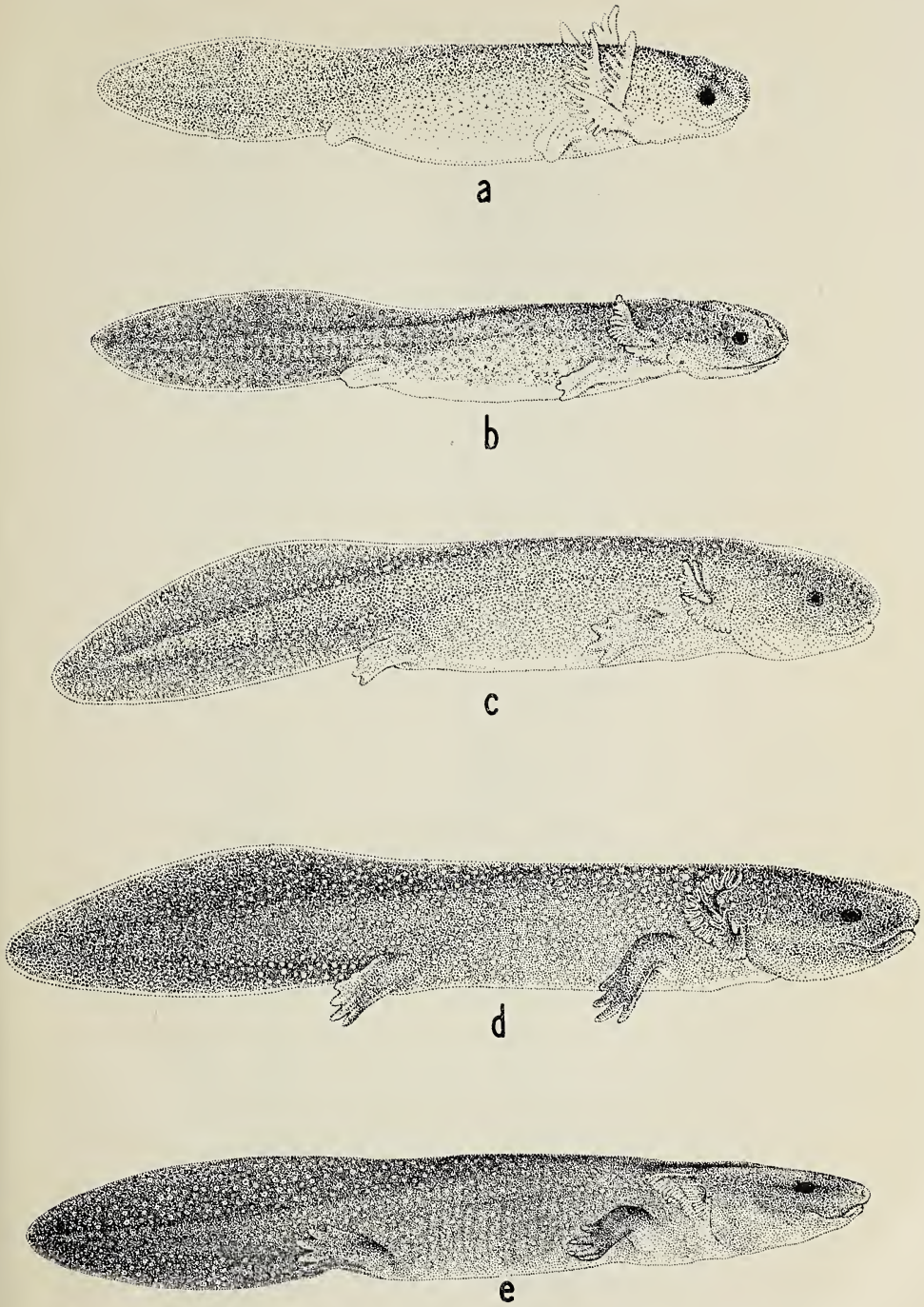


Fig. 11 *Cryptobranchus alleganiensis.* a. Larva at hatching, Allegheny river at Wolf run, Nov. 23, 1930. Actual length 29 mm. b. 12–13 days old, actual length, 31 mm. c. 30–31 days old, actual length 35 mm. d. 55–57 days old, actual length, 41 mm. e. 110–12 days old, actual length 37 mm. The yolk is almost entirely absorbed when 55 to 60 days old and in the absence of suitable food the larvae failed to grow and were actually shorter when 110 days old. H. E. R., del.

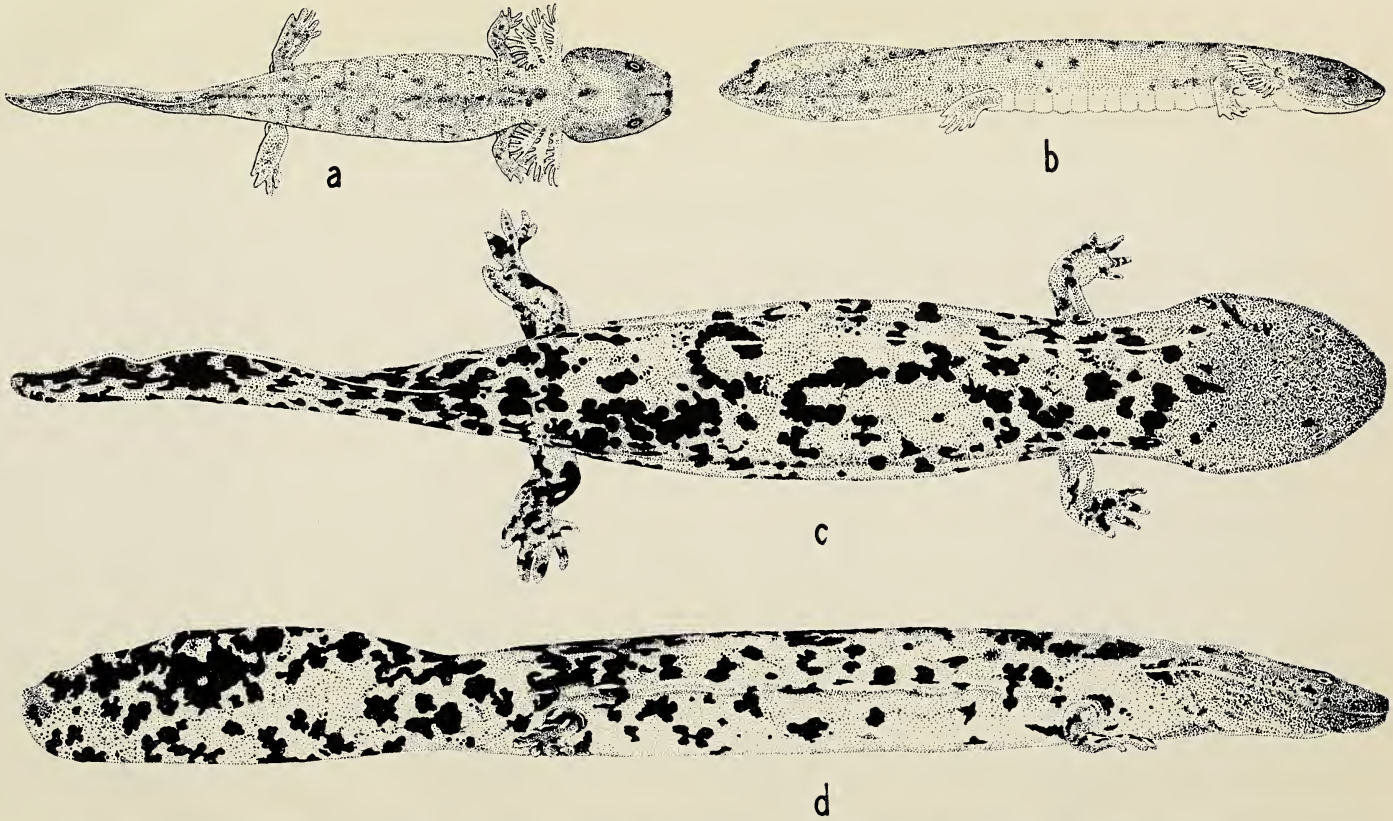


Fig. 12 *Cryptobranchus alleganiensis.* a. Year-old larva, dorsal view. French creek, Saegertown, Pa., May, 1930. Actual length 61.5 mm. b. Same, side view. c. Recently transformed individual, two years old, actual length, 125 mm. d. Same, side view. H. P. C., del.

Development

The egg and its envelops. The egg itself is perfectly round when freshly laid, 6 mm in diameter (average of 10), pale to bright yellow and without pigment. It is surrounded by a thin, transparent vitellus and floats in a thin fluid inclosed within the thick outer envelop. This external envelop is composed of a considerable number of concentric layers, the outermost of which are thicker than those toward the center. The fresh egg and its envelops measure about 18 by 20 mm. The eggs are joined by extensions of the outer, laminated layer to form a rosarylike string. (Figure 10*c*.)

The incubation period. The egg-laying season in the Allegheny river in western New York and Pennsylvania begins about the first of September and continues over a period of ten days or two weeks. Eggs deposited September 3–17, 1924, were hatching in the streams during the week of November 7–14, a period of incubation in this instance, of from 68 to 75 days. In 1925 at Meadville, Pa., fresh eggs were found September 1st. As with the eggs of other aquatic salamanders, the length of the period of incubation probably varies greatly, depending on the temperature of the water. In the Allegheny river at the mouth of Wolf run hatching eggs, and many at the point of hatching, were found on November 23, 1930. If these eggs were deposited about September 1st, as is usual in this locality, the period of incubation in this instance was about 84 days.

Smith (1912, p. 68) presented the following records pertaining to egg laying in streams of northwestern Pennsylvania:

1906	Aug. 30	1909	Aug. 29
1907	Sept. 8	1910	Sept. 1
1908	Aug. 28	1911	Sept. 4

At the time of hatching the egg envelops are greatly distended, measuring about 25 by 30 mm as compared with measurements of about 18 by 20 mm soon after the eggs are laid.

The newly hatched larva. Larvae at hatching are about 30 mm long. This length is the average of twenty selected at random from a lot taken the day of hatching from their nest, in which the extremes were 27 mm and 32 mm. At the time of hatching the larva is well pigmented above, darkest along the midline of the trunk in a broad band and on the head between the eyes. The tail is uniformly pigmented on both keels (figure 11*a*). The sides of the trunk are less strongly pigmented than the dorsal band and the

color gradually fades out to leave the belly free of chromatophores but brightly colored by the yolk. On the sides of the head the pigment extends to a line running from the angle of the mouth to the base of the lowermost gills.

Scattered over the surface of the trunk and head are small, round spots devoid of pigment and perhaps representing sense organs or mucous glands (Smith, 1907*a*, p. 23).

The mouth is well developed and apparently functional. The eyes are proportionally larger and more conspicuous than in the adult and are functional. The pupil and iris are black. The gills, of which the middle ones are longest, are provided with comparatively short, flattened filaments. (Larvae at five months have beautifully fringed gills as long as the head.) The buds of the fore legs bear the flattened, keel-like structures on the hind margins which are characteristic of the adult, and the buds terminate in two lobes representing two toes. The hind legs are thick, fleshy, paddle-shaped lobes directed backward. There is less indication of the keel on the posterior margins of the hind legs in this stage than on the fore. The tail is broad and flat, the dorsal keel extending forward to a point just before the insertion of the hind legs and continuing anteriorly as a low, rounded, fleshy ridge a short distance farther.

During the first few weeks of their existence, the larvae develop rapidly, their legs and toes being fully formed when two months old and with the free flaps of the hind margins of the legs well formed.

The length of the larval period. The material upon which the estimate of the length of the larval period is based includes 12 specimens averaging 57.08 mm in length taken during the last week in May 1930 in a shallow backwater of French creek near Saegertown, Pa. These specimens were collected by Paul A. Webb from beneath stones within an area about 20 feet square and in close proximity to a large flat rock near shore which gave evidence of covering the site of a nest. Sixteen additional specimens taken during the summer months varied in length from 97 to 137 mm.

First year. The larvae taken in May varied in length from 53 to 63 mm and represented the growth, following hatching, of approximately 6½ months or about nine months from the time of egg laying. Four larvae collected by Smith (1907*a*, p. 35) in August, which, presumably, hatched the preceding autumn or early winter, measured 64, 68, 70 and 73 mm respectively and averaged 68.7 mm. These specimens were thus approximately one year from the time of

egg laying, and 68 to 70 mm may be taken as about the length attained by the hellbender during its first year.

At the age of one year the gills are retained but somewhat reduced. The legs are well developed, with the hind margins somewhat flattened, particularly on the fore legs. The body is less depressed than in the adults and the lateral folds are indicated in some specimens by a low ridge. The gular fold, however, is well developed in this stage though lacking in the adult.

The general color of the dorsal and lateral surfaces is deep brown which largely obscures the scattered, irregular dark spots. A few small, irregular yellow spots are also present though not conspicuous.

Second year. The 16 specimens taken during the summer of 1930 averaged 114.5 mm and presumably were in their second year. The measurements agree substantially with those obtained by Smith (1907*a*, p. 36) who found two larvae measuring 120 and 123 mm respectively.

The largest specimen in the series of 16 had a total length of 137 mm and showed no evidence of gills. The largest specimen with gill rudiments measured 133 mm in total length and the smallest specimen without gills measured 107 mm. Seven of the 16 specimens without gills or rudiments averaged 120.8 mm, as against 109.5 mm for the remaining nine specimens with gills or rudiments.

The gills, where present, are smaller than those of year-old larvae and the gular fold is greatly reduced or entirely lacking. The two-year-old larvae differ otherwise from the year-old larvae in the more depressed form of the head and trunk, in the greater development of the keel on the hind margins of the legs and in the somewhat more prominent lateral folds. The most evident change is in the development of the color pattern. In specimens in their second year, the ground color is somewhat lighter and the dark spots more numerous and much more strikingly developed.

Development to maturity. I have not had sufficient material to determine to my satisfaction the length of the period of development to sexual maturity. Smith (1907*a*, p. 38) found that maturity was attained at a length of about 340 mm and estimated the period at from three to four years from the time of fertilization. Of six immature specimens taken by Smith in August some represent age groups between the second-year larvae and adults. Their measurements were: 140, 162, 183, 210, 215 and 267 mm. All specimens had lost the external gills and were sexually immature. In color they were generally like young adults. From the scant evidence of

these few specimens, I would be inclined to the opinion that sexual maturity is more likely to be attained during the fifth or sixth year.

Habits

General. The hellbender is perennially aquatic and usually confined to running water of rivers and large streams. Generally speaking, it is nocturnal; but may sometimes be observed during daylight hours moving slowly over the bottom. This is particularly true in the breeding season but at other times they congregate in sizable schools when moving from one part of the stream to another. As dusk approaches, many individuals may appear and forage openly among the stones and stranded logs. It is also possible to arouse the animals from their hiding places by placing the bleeding carcass of a recently killed animal in the current of the stream. Following the scent of the blood, the animals may be seen plodding along, strung out in a long line and actively searching for the source of a possible food supply.

The hellbender is seldom observed to swim freely in open water unless disturbed. Its ordinary method of progression is a rather slow crawl, the diagonally opposite legs moving together. When pressed, however, it swims vigorously for a short distance, the broadly keeled tail being thrown in wide lateral undulations. The fleshy keels on the hind margins of the legs sometimes serve when the animal rises to the surface to swallow air.

Food. The food consists principally of crawfish, small fish, mollusks, worms, insects and animal refuse of almost any character. Shortly after being captured, a specimen 22 inches long disgorged a piece of fat meat over a foot in length. The hellbender also sometimes eats its own eggs and young but digestion is slow and not many are taken.

Respiration. The lungs of the hellbender are well developed and are brought into use when the animal is confined in still water. At frequent intervals it rises to the surface and with the mouth closed, the throat is expanded and the air drawn in through the nostrils. Part of the air thus taken escapes at the corners of the mouth or through the gill slits but enough is retained to expand the lungs. When the lungs are fully distended the animal may float with part of the back exposed above the surface, the tail hanging down and the snout just below the surface. This position may be maintained for a considerable time and it is apparently necessary to expel some of the air before it is possible to sink again to the bottom. The

conspicuous lateral folds of the body give greater surface contact with the water as an aid to respiration. When guarding the eggs in the nest and in still water aquaria, the hellbender frequently rocks the body from side to side and throws the folds into wavelike undulations. The eggs are certainly aërated in this manner and it is not at all unlikely that the animal itself receives considerable benefit from the water thus set in motion.

Habitat

I have found the hellbender most abundant in running water. Although they frequently make their way into shallow streams and will sometimes excavate their nests where the water is scarcely deep enough to cover the sheltering stone, the species will be found in greatest abundance where the water is a foot or two in depth and the current is fairly swift. Thirteen large specimens were taken in the course of an hour in a stream where the water flowed so swiftly that it was extremely difficult to retain a footing. It is usually useless to search in streams where the bottom is not covered with large slabs of rock or with sunken logs and old water-soaked boards. To serve as suitable nest sites, the rocks and stones or sunken logs must be at least partially imbedded, otherwise the swift current tumbles the eggs down stream as fast as they are deposited. Objects lying loosely on the surface serve as shelters for nonbreeding specimens, spent females, superfluous males, and for the young of various sizes and, under such cover, specimens may be found almost any time of the year. It is also quite likely that the excavations which serve as nests are occupied more or less continuously.

Remarks

In the early accounts of the hellbender, the animal was frequently confused with *Necturus*. Thus in Barton's (1807, p. 196) description of a large salamander which he called the hell-bender, it is evident from the account of the range of the animal that *Necturus* was partly involved. Mitchill (1824, p. 63) also confuses the two species after having pointed to the correct relationship of *Necturus* in 1822. Say (1818, p. 407) believed that the animal *(Necturus)* described by Schneider from Lake Champlain was probably the young of the hellbender and this view was also expressed by others. Rafinesque (1820, p. 4), on the other hand, regarded *Salamandra alleganiensis* as belonging to *Necturus*.

DeKay (1842, p. 89), on the authority of James Hall, seems to have been the first to record the hellbender from New York waters.

He writes: "I have never met this animal myself in this State; but Prof. Hall assures me that he has seen it in the Allegany river, one of the tributaries of the Ohio, within the limits of this State." J. H. McGregor (Proc. N. Y. Acad. Sci. 1896) seems to have been the first to describe the embryo.

Range

The range of *Cryptobranchus* as given by Stejneger and Barbour (1933, p. 3) is as follows: "Western New York, Ohio River and tributaries, and southward to Georgia and Louisiana." This is not exactly correct. It is incomplete in the omission of the Susquehanna river and its larger tributaries from the range of the animal. Baird (1850, p. 290) and Cope (1889, p. 42) recorded the species from this river in Pennsylvania (U. S. N. M. No. 10043) and we have since taken it in the Unadilla river and in the Susquehanna at a number of localities.

The distribution, as at present known, may be summarized as follows: The Susquehanna and tributaries in New York and Pennsylvania; the Ohio river and tributaries including the Allegheny in western New York; the Mississippi river and tributaries; Iowa and southward to Louisiana on the Gulf coast and Georgia on the Atlantic coast.

Fig. 13 New York localities for *Cryptobranchus alleganiensis*.

Distribution in New York

General. The hellbender in New York is restricted to the Allegheny and Susquehanna rivers and their larger tributaries.

Specific Records. ALLEGANY: Allegany county (Yarrow, 1883, U.S.N.M. No. 7068; Cope, 1889); *Oswayo creek, Ceres.* Aug. 30, 1926, 2 half-grown, N. Y. S. M. No. 3084 (Bishop, 1927). BROOME: *Susquehanna river, Binghamton,* Oct. 1931, 1 ad., C. U.; *Windsor,* Aug. 2, 1935, 1 juv., U. R. No. 3879; *Center Village,* Aug. 1935, abdt. CATTARAUGUS: *Allegheny river,* mouth of Wolf run, Aug. 31, 1926, 7♂. N. Y. S. M., No. 3080–3083 (Bishop, 1927); Sept. 1, 1926, 4♂, 3♀, N. Y. S. M. No. 3065, 3079, 3281 (Bishop, 1927); Aug. 15, 1927, 3 ads. (R. E. Coker and W. P. A.); Nov. 23, 1930, 9 ads., U. R. No. 1236, 1278–85, and many hatching young; Sept. 21, 1931, sev. ads. of both sexes; Oct. 10, 1931, 13 ads. of both sexes; Oct. 22, 1932, 3 ads.; Oct. 28, 1933, 2 ads.; Oct. 19, 1935, 6 ads., eggs; Oct. 9, 1937, sev. ads.; Oct. 15, 1938, 4 ads. *Allegheny river* below *Elko Mt,* Aug. 15, 1927, 6 ads. (H. Marchand); *Ischua creek, Ischua,* Oct. 15, 1933, 1 ad., 1 juv. (S. C. B., Ralph Odell and C. R. Crosby); Oct. 29, 1933, 8 ads. U. R. No. 3435; *Salamanca,* Aug. 1926, C. M. No. 4054 (W. P. A.). CHENANGO: *Unadilla river, Greenwood cove,* near *New Berlin,* Aug. 1935, sev. ads.; *Rockdale,* May 1923, 1 yg. (Cole); May 1927, 3 ads. (Cole); June 11, 1928, 1 ad. ♀ N. Y. S. M. No. 4796 (Cole); *Susquehanna river, Afton,* summer 1935, abdt. DELAWARE: *Susquehanna river,* Sidney, Aug. 1935, abdt.

Records too indefinite to be placed under counties: Western New York (Allen, 1869; Cope, 1889; Pratt, 1923; Stejneger and Barbour, 1923); *Allegheny river* (Harlan, 1825; DeKay, 1842; Eckel and Paulmier, 1902); headwaters, *Allegheny river,* 1876, 3 ads., M. C. Z. No. 1281 (Dunn, 1918). The specimens recorded by Yarrow, 1883, p. 146 and Cope, 1889, p. 42, from the Great Lakes, U. S. N. M. No. 9205, were doubtless mislabeled. Dunn, 1918, p. 446, also records a specimen labeled, "Cayuga lake," in the collection of the Museum of Comparative Zoology at Cambridge, No. 2009, which is also an error.

Condensed Bibliography

Life history and habits. Alexander 1927, p. 13–18 (*Cryptobranchus Allegheniensis*); Bishop, 1927, p. 36–38 (*Cryptobranchus alleganiensis*); Boulenger 1914, p. 265–66 (*Cryptobranchus*); Hay, 1892, p. 423–25 (*Cryptobranchus alleghaniensis*); Netting 1929, p. 23 (*Cryptobranchus alleganiensis*); McGregor, 1896, p. 73 (*Cryptobranchus*); Reese, 1903, p. 526–31 (*Cryptobranchus alleghaniensis*); Reese 1904, p. 220–23 (*Cryptobranchus Allegheniensis*); Reese 1906, p. 93–99 (*Cryptobranchus allegheniensis*); Smith 1882, p. 716–17 (*Menopoma alleghaniensis*); Smith 1907*a*, p. 3–39 (*Cryptobranchus allegheniensis*); Smith 1912, p. 61–89; Surface 1913, p. 82–85 (*Cryptobranchus alleganiensis*); Townsend 1882, p. 139–140 (*Cryptobranchus alleghaniensis*).

Distribution in New York. Allen 1869, p. 202 (*Menopoma alleghaniensis*); Bishop 1927, p. 34–38 (*Cryptobranchus alleganiensis*); Cope, 1889, p. 38–42 (*Cryptobranchus allegheniensis*); DeKay 1842, p. 89 (*Menopoma alleghaniensis*); Dunn 1918, p. 446 (*Cryptobranchus alleganiensis*); Eckel and Paulmier 1902, p. 398 (*Cryptobranchus allegheniensis*); Harlan 1825, p. 225 (*Salamandra Alleghaniensis* and *Abranchus Alleghaniensis*); Ruthven 1909, p. 331; Pratt 1923, p. 148 (*Cryptobranchus alleganiensis*); Stejneger and Barbour 1923, p. 3; Yarrow 1883, p. 146 (*Menopoma allegheniensis*).

TRITURUS VIRIDESCENS VIRIDESCENS (Rafinesque)

(*Triturus viridescens,* Ann. Nature, Lexington, Ky. No. 1, Mar. 22, 1820, p. 5)

Newt, Water Lizard, names of aquatic forms; Eft, Ebbet, Little Red Lizard, names given to the usually immature, land form.

Figures *2g, 4c,* 14–17

The newt is one of the most common and widely distributed of our salamanders and, because it is often abroad during the day, it is probably more frequently observed than any other species.

Description

Size. Aquatic adults. In the discussion of the newt, the aquatic adults and the land forms or "Efts" are treated separately. The aquatic adults vary considerably in size in different localities and often to some extent in different waters in the same general locality. There is even some variation in the average size of adults taken in the same waters in different years, although the data covering this phase of the subject are too meager at present to permit general statements. The measurements presented below give some idea of the size attained by adults in several distinct localities.

A series of adult females taken in Long Pond, Rensselaer county, N. Y., vary in length from 79 to 95 mm and average only 86.6 mm (3⅜″). The males from the same pond average 94.6 mm (3¾″) with 90 and 98 mm as the extremes. In the females the tail comprises from 49.3 to 52.9 per cent of the total length; in the males from 50 to 52 per cent.

A series of 105 adults from Newfoundland, N. J., recorded by Noble (1926, p. 10) averaged 84.75 mm with extremes of 104 and 63.5 mm. Fifty-seven adults from Victor Edward's pond, Long Island, N. Y., averaged 91.61 mm in length and varied from 120 to 79 mm.

Thirty-one males taken at Syosset, Long Island, N. Y., averaged 81.1 mm in length with extremes of 65 and 96 mm, while 18 females averaged 82.9 mm with extremes of 67 and 93 mm. In this series the females averaged slightly longer than the males but perhaps a greater number of specimens should be measured before drawing conclusions.

One hundred fifty-five males from a pond near East Nassau, N. Y., taken May 1, 1928, averaged 90.64 mm with extremes of 76 and 110 mm. The 23 females taken at the same time and place averaged 84.5 mm in length with 74 and 97 mm as the extremes. One hun-

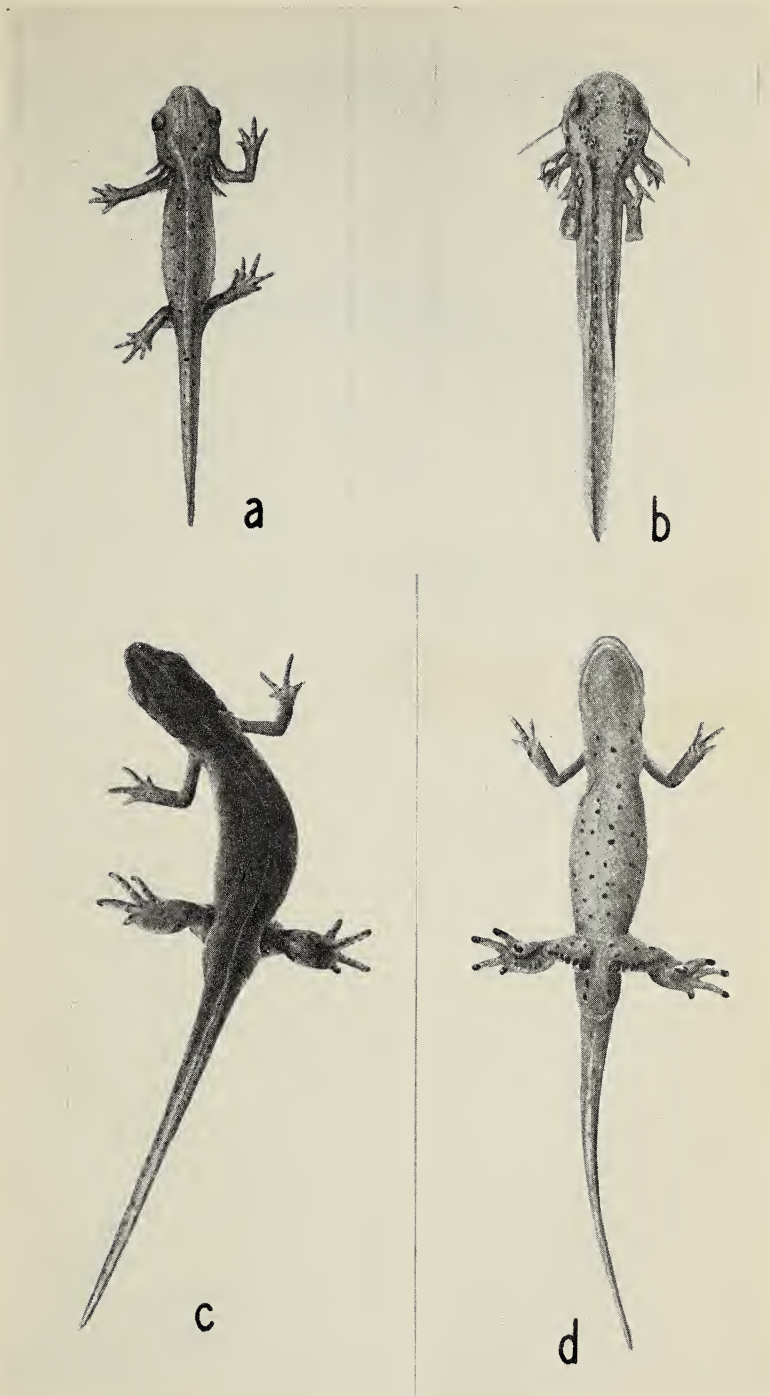


Fig. 14 *Triturus viridescens viridescens.* a. Fully grown larva, X 2. Albany, N. Y., Sept. 28, 1924. b. Larva at hatching, X 8. Albany, N. Y., May 23, 1924. c. Adult male, dorsal view, X 1, Galway, Saratoga Co., N. Y., Apr. 29, 1924. d. Same, ventral view. Note sexual excrescences on under surface of thighs and toes of hind feet. b, c, and d, E. K. O'B., del.

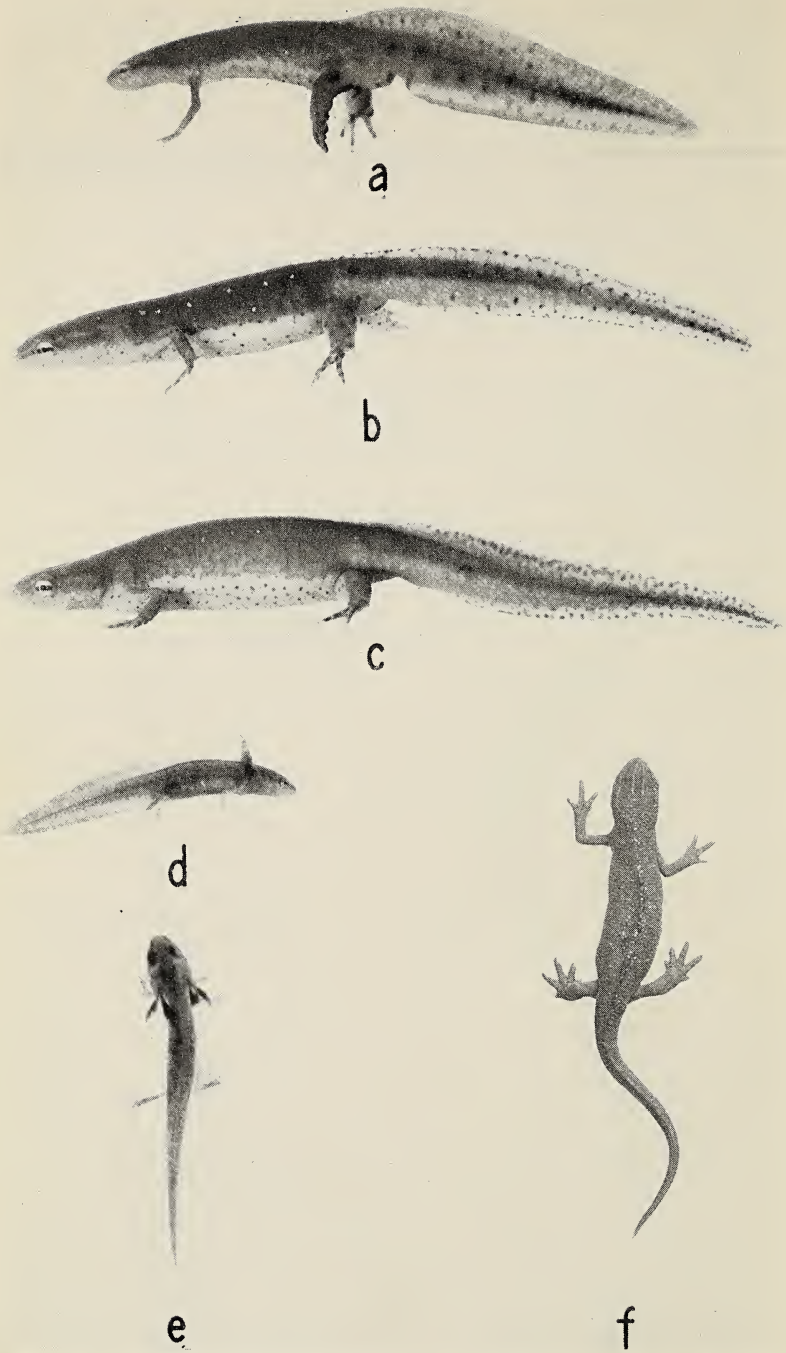


Fig. 15 *Triturus viridescens viridescens.* a. Adult male at height of breeding condition. East Nassau, N. Y., May 10, 1928. b. Adult male, another individual, in late summer. Thacher Park, N. Y., Aug. 31, 1927. c. Adult female, Thacher Park, Sept. 3, 1927. d. Fully developed larva, side view, East Nassau, N. Y., Aug. 12, 1927. e. Larva, back view. f. Eft, Voorheesville, N. Y., Nov. 4, 1922. Photo by E. J. S.

dred seventy-six specimens of both sexes from Clear (Heart) lake, Adirondack Lodge, N. Y., averaged 81.15 mm with extremes of 71 mm and 95 mm.

Eft. In considering the land stage, it is essential to keep in mind that the length of this period varies greatly in different localities and even considerably among individuals in the same locality. A series of efts taken August 28, 1927, in the woods bordering Cossayuna lake, Washington county, N. Y., fell into three definite groups when arranged according to size, indicating that at this particular locality some individuals at least were in their third year of sojourn on land.

The measurements of the members composing the three groups are given below in tabular form:

	Group 1	*Group 2*	*Group 3*
Extremes	47–56 mm	60–69 mm	70–87 mm
Average length	50.7 mm	63.5 mm	76 mm

With a single exception, these specimens were all in the brilliant coloration typical of upland efts found in cool, moist situations. The single exception, the largest specimen 87 mm long, was yellowish green, quite like some individuals recently returned, or preparing to return, to water. Based on measurements alone, it would be reasonable to suppose that the members composing the three groups were respectively in their first, second and third years on land following transformation. The general bodily conformation of the specimens also supports this view. The measurements of individuals of the two groups of larger specimens fall within the limits of size of specimens, mature or approaching maturity, found in migration to ponds or in the ponds themselves. This is very nicely demonstrated by the measurements of a series of newts taken in migration to a breeding pond in Rensselaer county, N. Y., and suggests that sexual maturity, at this locality, is attained by some individuals during their second year and that others are in their third year. These migrating individuals varied in length from 61 to 89 mm and in color from bright red through varying shades of greenish yellow to olive-green. The red specimens averaged smaller than the others and were taken in greater numbers in August than later in the season.

Form. Here again, the several phases in the life history of the newt require separate description. In the aquatic adults, the body is somewhat compressed, the head comparatively narrow and the tail narrowly keeled above and below. Along the midline of the back

there is a low ridge continuous with the dorsal tail keel and extending to the head where it meets the two parallel cranial ridges that converge on the snout. The sides of the head converge gradually to the eyes, then more abruptly to the rather pointed snout. The eyes are large, the horizontal diameter being about equal to the distance between the anterior canthus and the nostril. The mouth is subterminal and extends on the sides of the head to a point opposite the posterior canthus of the eye. The margins of the upper jaw near the angle of the mouth are thin and extend in a flaplike fold over the upper margin of the lower jaw. The gular and costal folds are not developed. The tongue is small and fleshy without free margins. The vomeropalatine teeth are in two long, converging series that extend forward between the inner nares. The legs are well developed, particularly the posterior pair. The toes are 5-4, the first and fifth rudimentary on the hind feet, the others in order of length 2-4-3. On the front feet the inner toe is rudimentary, the others 4-2-3. The skin is comparatively smooth.

In the typical land stage newt (red eft) the body has a more rounded contour, the tail is scarcely, if at all, keeled and the skin is decidedly rough. The cranial ridges appear to be more conspicuous. As they approach maturity they gradually assume the characters of the adults.

During the mating seasons the tail fins of the male reach their highest development, the hind legs are enlarged and on the inner surface of the thighs and tips of the toes there are black corneous excrescences. In the females there is some widening of the tail keels, but not to the extent found in the males.

Color. The color is variable. In the aquatic adults the general ground color above is olive green varying, however, through shades of yellowish brown to dark greenish brown in different individuals and at times the same individual may undergo considerable change within a few hours. Much depends on the character of the water in which the newts are found. In clear, open waters with light, sandy bottoms, newts are usually lighter in color than those found in the dark waters of swampy areas, or where there is considerable vegetation and shade.

The dark dorsal color extends on the sides of the head to about the lower margin of the eye, on the trunk low enough to involve the upper half of the legs and on the tail about the upper half. The throat, belly, lower surfaces of the legs and lower half of the tail vary from light to bright yellow. Scattered irregularly over both

upper and lower surfaces are flecks and spots of black pigment which vary in size from minute points to blotches of considerable size. Often the dark spots on the back may coalesce to form patches two mm in diameter, while those of the belly remain very small. On either side of the midline of the back there is a series of bright red, black bordered spots varying in size from one to two mm and in number from one to 12 or more but usually averaging about five or six. These spots may be confined to the trunk but a few are usually present on the sides of the head. Rarely a second irregular series is developed on the lower sides. Occasionally a specimen will be found lacking the red spots or with these developed in great numbers.

The dark color of the back and upper sides does not fade gradually into the lighter belly, but ends abruptly in a well-marked line along the sides that is frequently made conspicuous by a series of small black dashes or spots. This narrow line is sometimes continued to form a definite longitudinal stripe along the middle of the lower half of the tail. In specimens so marked, the extreme lower margin of the tail fin often bears a series of dashes or a broken line of black, giving the tail a striped appearance.

The bright red of the typical eft is acquired gradually after transformation. Individuals kept in captivity, however, failed to develop brilliant coloring during the several months period of confinement; while specimens taken in the field, presumably of the same age, had developed the color in the brightest hues.

In certain damp wooded areas large series of uniformly bright red efts may sometimes be collected but in other localities the color varies in different individuals from dull reddish through shades of red orange to brilliant red. As the animals approach sexual maturity, individuals will be found of varying shades of brown, yellow, greenish and olive, the changes taking place either on land or in water. The black bordered vermillion spots are present in the efts as in the adults.

On Long Island (where the red land stage is less common and where some individuals may remain in the water throughout life) the color is never developed so highly as in cooler, damper situations. The color is deep red, not distinctly brownish as in individuals that are forced to spend the period of hibernation on land because of the drying up of the ponds.

Sexual differences. The adult males average somewhat larger than the females in most instances where I have measured a con-

siderable number of specimens. Thus in a series of twenty males from East Nassau, N. Y., the average length is 97.5 mm with extremes of 82 and 110 mm. Twenty females from the same pond, taken at the same time, average 83.5 mm with extremes of 74 and 97 mm.

In Long Pond, Rensselaer county, N. Y., the males averaged 94.6 mm in length, the females 86.6 mm. This is not in agreement with the findings of Jordan (1893, p. 271) who remarks: "The females are slightly larger and in the breeding season considerably heavier than the males."

During the mating seasons the males acquire conspicuously broad tails, some measuring 14 to 15 mm at the widest part, which is just behind the vent. In large females the tail at its widest part may be only 8 or 9 mm. In the males the dorsal fin of the tail, which is frequently wavy, extends forward to, or somewhat beyond, the front margin of the hind legs and is broadly rounded up above the line of the back; in the females the dorsal fin at most extends only to the hind margin of the legs and is nearly straight.

The hind legs of the male are much larger than those of the female and bear, during the mating periods, horny black cross ridges on the inner surface of the thighs and horny black excrescences on the ends of the toes. These excrescences may be fully developed before the tail fins become at all broadened and before the breeding ponds are reached. In a series taken in migration, May 1, 1928, all individuals lacked the broad tail keels and some retained the reddish and yellowish brown colors characteristic of newts deserting the terrestrial and preparing to take up the aquatic mode of life. In this series were 18 males and of this number 14 had the excrescences well developed when taken. Over night another male developed the excrescences and by May 5th the remaining three specimens had developed them. The broad tail of the male is likely to be marked irregularly with large oval black spots, while on the tail of the female the spots tend to be arranged in longitudinal lines that give a striped appearance. Generally speaking, the females are inclined to be more uniformly greenish in color, while the males take on brighter hues of orange and yellow, particularly on the fins.

During these seasons too, the vent of the male becomes protuberant and when everted, as in the act of depositing a spermatophore, presents to the surface a considerable number of fine tubules and two backward directed yellow lobes bearing long and tapering tubules. The vent of the female is likewise somewhat protuberant but never to the extent found in the male. It is shorter than in the male and

is usually marked with a series of narrow black-edged ridges that converge to the slit.

Three or four large, shallow, sensory pits are developed on the sides of the head of the male, larger and much more conspicuous than any similar structures which may appear on the female. These pits reach their full development in the adult male and function during the courtship when the sides of the head of the male are pressed to the snout of the female.

Activities of the Breeding Season

Migration. Definite migrations are undertaken in the fall and in the spring, different individuals, of course, participating. Ordinarily only those approaching sexual maturity make the journey back to the ponds.

While both sexes are represented in the fall migration, the males, in my collections, are never so fully developed as the males taken during the spring migration. They lack the sexual excrescences which are so frequently well developed by spring migrating males even before the ponds are reached. It is a question, therefore, whether males which migrate in the fall are sufficiently mature to participate in the fall mating activities.

On August 17, 1927, there was a definite migration of newts to a breeding pond near East Nassau, N. Y. Within a small area 35 specimens were collected, some as they plodded along toward the pond in broad daylight, others from beneath chips and stones lying on the surface of a shaded wood road. The banks at the sides of the road were steep and acted as a partial barrier. Five days later 13 additional specimens were collected from beneath the same small shelters. On September 7, 1927, 25 additional specimens were secured in the same manner. An attempt was made to collect other specimens later in the season but with little success, only one or two being found. That the migration had begun sometime before the first specimens were collected on land (August 17th), was evidenced by the number of newts already in the pond which still retained their rough skins, narrow tails and reddish or yellowish colors. As before mentioned, under the paragraph dealing with the size of land stage newts, these migrating individuals varied in length from 61 to 89 mm.

It is perfectly evident that the migration of newts to the breeding ponds is not restricted to the fall of the year. Forty-five specimens were taken May 1, 1928, along the same wood road on their way to

the pond. These were in the flooded ruts of the road or hiding in the herbage bordering the ruts. Of the 18 males, all had narrow tails, fairly rough skins and yellowish green coloration. All but four, however, had developed the sexual excrescences. The 45 specimens taken May 1, 1928, varied in length from 65 to 87 mm and averaged 78.2 mm.

Dunn (1930, p. 3) observed the migration of the land form at the edge of a pond on Mount Toby, September 23, 1917. Since actual mating and egg laying does not take place until spring, the fall migration probably should not be regarded as a definite activity of the breeding season.

Mating. With the newt there is a fall mating period during which the fully mature male wears the sexual excrescences, bright colors and broad tail-keels. He noses and clasps the female and may even deposit spermatophores, but, so far as now known, the female at this time does not deposit eggs. The mating antics of the male may be continued at intervals throughout the winter but actual mating and egg laying begins in the spring.

The males appear to outnumber the females and the discrepancy is particularly apparent during the breeding season when the animals are less timid and the sexes may easily be distinguished in the field. At this time a number of males may often be found in pursuit of a single female and it is not at all unlikely, in view of the length of the egg-laying period, that several males may succeed in mating with each available female.

Jordan (1891, p. 267) has given an excellent description of the courtship and mating activities of the newt and the following paragraphs are taken from his account:

> In many cases an interesting courtship precedes the actual clasping of the female. As soon as the male becomes aware of the presence of the female in his neighborhood, he becomes somewhat agitated, and usually begins to move stealthily towards the female with an air of exaggerated caution. It not infrequently happens that the latter, on perceiving his approach, darts away in a state of great excitement, and has to be patiently approached again and again by her unwearied suitor. When the male is finally allowed to come into the immediate neighborhood of the then passive female, he usually enters upon a series of contortions resembling those witnessed at the time of the discharge of the spermatophores. After a few seconds of this suggestive "Vorspiel" the male vaults quickly upon the back of the female and clasps her tightly around the body with his strong hind legs. When the animals have been for some time in captivity, or a number of individuals of both sexes are together in one aquarium,

this deliberate courtship is not observed, and the male clasps the female without any ceremonious preliminary. It often happens that he first catches the female by the hinder part of the body, but if he retains his hold for longer than a few minutes, he invariably moves forward until he has the female securely clasped under her throat, either directly before or directly behind her fore legs. Once in this position no attempt of the female can dislodge him, and he may cling there for hours. On a number of occasions I have seen females appear much the worse for this rough usage, and on one occasion an apparently robust female lay as if dead for several hours after the male had left her, although she eventually revived.

When the male is thus mounted, a period of comparative quiet ensues, lasting from thirty minutes to several hours in individual cases. During this period the animals remain on the floor of the aquarium in almost exactly the same spot, and the male is not, as incorrectly stated by most observers, "jerking the female unmercifully around during the whole time." On the contrary, both animals are well-nigh motionless, with the exception of the often-described fanning movement of the tail of the male. This half-stroking, half-fanning motion is kept up with more or less rhythmical regularity, first on one side and then on the other, and probably serves to excite both animals, although heretofore it has been not unnaturally regarded by many observers as for the purpose of diffusing the spermatozoa throughout the water. The female responds by slowly raising her tail until it forms an angle of 45°, or even a right angle, with her body, and occasionally repeats in her turn the slow fanning movement.

From this condition the male passes gradually into a more violent stage, which has been wrongly stated by some writers to extend over the whole of the foregoing period. This more violent stage usually lasts for only about ten minutes, and during this time the unhappy female is dragged, jerked, and pulled over the whole floor of the aquarium, the entire body of the male meanwhile quivering with intense excitement. The cloaca of the male at the same time begins to swell and to show a few whitish papillae projecting from the sides. At the climax of his agitation the male, after a few rapid bendings of his body from side to side, leaves the female, and with his tail slightly raised, his cloaca widely distended with numerous white protruding papillae, throws his whole body into a series of rapid and strenuous undulations, and waits for the female to follow him. If she does this and presses her head lightly against his tail and cloacal region, the male soon deposits a spermatophore and then creeps on to a distance of a few centimeters, where, if the female still continues to follow him, he soon deposits another. I have often seen one male discharge as many as three spermatophores in this way, but have never seen one individual discharge at one time more than this number.

I may add from my own observations, which confirm those of Pope (1924, p. 317), that the everted vent of the male is frequently

pressed to the back of the female during the period when the sexes are together and that the fanning movements of the tail may be made to waft the products of the cloacal glands of the male toward the head of the female. The tip of the tail is directed toward the head and vibrated slowly from side to side, then turned about to the other side and again vibrated.

Spermatophores. The spermatophore of the newt consists of a broad, flat, irregular, disklike, gelatinous basal part from which arises a stiff, elastic, tapering, spinelike structure, which, in turn, is surmounted at the tip by a spherical mass containing spermatozoa. The spine may attain a height of five or six mm and the sperm mass a diameter of one to one and one-half mm.

A considerable number of spermatophores are deposited by the male, a few of which may subsequently be utilized.

The egg-laying process. The eggs are normally deposited singly and fastened to leaves and stems of aquatic plants or, more rarely, to the surface of stones in quiet or slowly moving water. When depositing her eggs, the female grasps the support between her hind legs, draws her thighs closely together so that the toes often overlap and forces the eggs out one at a time. The leaves or stems stick closely to the envelops so that in many cases the egg is concealed.

In the vicinity of Albany, N. Y., egg laying begins about the middle of April or a little later and continues through May. When the season is backward, the deposition may continue throughout June or later, a period of six to ten weeks. In any event, with the newt, egg laying is a long, drawn out process, a few being deposited each day. Judging from dissections, a single female may mature as many as 376 eggs in a single season but there is little evidence to support the view that all may be deposited. In five adult females taken May 11, 1928, near Albany, N. Y., the well-developed, pigmented eggs numbered respectively, 232, 297, 376, 339 and 266. These females measured, in total length: 122 mm, 116 mm, 109 mm, 112 mm and 110 mm. A single female, however, taken May 6, 1924, had only 40 eggs in the right ovary and 43 in the left, which were large enough to warrant the belief that they might be laid that season.

Females in captivity, although often feeding freely, deposit fewer eggs. Four large individuals, during a period of four to six days, deposited 17, 17, 18 and 20 eggs respectively and although retained in suitable aquaria for a considerable period, they failed to deposit

additional ones. Jordan (1893, p. 276), however, reports the deposition of 107 eggs by a female in captivity.

Development

The egg and its envelops. The egg of the newt has a diameter of about 1.5 mm; with its elliptical envelops the total measurements are, short diameter 2.42 mm, long diameter 3.57 mm (average of seven). Immediately surrounding the egg is the vitelline membrane which is not ordinarily distinguishable until segmentation has broken the smooth contour of the egg. The envelop next without is elliptical and incloses a thin fluid in which the egg floats. Outside of this layer are two thin layers, the outer of which is tough and covered in all specimens I have examined, with fine, hairlike filaments as if it had been in contact with cotton, and some of the fibers had adhered. The upper pole of the egg varies from light to dark brown, the lower pole is light yellowish green.

The incubation period. As in the case of other salamanders whose eggs are deposited in water, the length of the period of incubation is extremely variable depending on the temperature. At a room temperature of about 68° F. eggs hatch in from 10 to 16 days. Out of doors under natural conditions, the period may extend from 20 to 35 days. Eggs were found in the field May 7, 1924.

The newly hatched larva. At hatching, larvae have an average length of about 7.5 mm. The gills are developed but only slightly branched and balancers are present and attached midway between the eye and anterior gill. The front legs are represented by rather short and blunt buds but rapidly elongate within a few days. The broad tail keel is continued along the midline of the back to a point almost opposite the third gills. The balancers may be retained five or six days or lost in two.

The general color above is light yellowish green with a pigment pattern of gray. On each side of the middorsal line the pigment is more or less concentrated into two rather broad bands, which extend the whole length of the body and separate slightly on the head. Another line composed of irregular small spots extends through the eye on each side and spreads out on the side of the head to include the gills. The sides of the body below the dorsal bands are also pigmented but less densely. The tail keels are slightly pigmented above and below. The belly is pale yellowish and without pigment except for a few flecks over the heart.

Length of the larval period. I have found fully transformed newts as early as August 17th and thereafter until September 15th in the region about Albany, N. Y. Egg laying here often begins as early as April 15th, but since the water remains cold, development is slow and the eggs may require 35 days to hatch. In some years larvae may appear as early as May 20th and, if the first transform about the middle of August, there is a larval period of approximately 84 days.

Mature larvae. In the mature larva the body is slender and wedge-shaped. The head is broadest just in front of the gills and tapers to the blunt snout. The gills are long, flattened dorsally and provided with many flat filaments which give a brushy effect. The legs are well developed and functional. The dominant color of the mature larva in life is very pale gray or pale yellow with tinges of light gray, pale green or light orange and is not, as has been stated by authors, the color of the aquatic adult. Black chromatophores in minute flecks are scattered generally over the surface, and on the gills, legs and dorsal ridge are aggregated to form scattered spots of considerable size. On the tail are irregular blotches free from black pigment and varying in color from yellow to bright orange-yellow. There is a conspicuous dark bar through the eye and on the sides there is a series of small, white dashes extending from the gills to a point back of the hind legs where it bends abruptly upward and follows the contour of the tail at the base of the dorsal tail fin. These pigment-free dashes indicate the position of the lateral line sense organs.

Larvae taken August 12, 1927, in a pond at East Nassau, N. Y., varied in length from 28 to 40 mm. On this date, some individuals regarded as fully developed possessed broad dorsal keels and tail fins and bushy gills; these varied from 35 to 39 mm and averaged 36.7 mm. Those individuals beginning transformation, as indicated by the reduced gills and fins, varied in length from 33.5 to 40 mm and averaged 36.8 mm; those with well developed gills and dorsal keels only slightly reduced, varied from 28 to 37 mm and averaged 32.7 mm. No fully transformed individuals were found at this time.

Twenty-five of 36 larvae taken at the same locality August 17th, had well developed dorsal keels and bushy gills. These varied in length from 26 to 39 mm and averaged 33.6 mm. The eleven individuals with reduced gills and fins averaged 35.27 mm, with extremes of 31 and 39 mm.

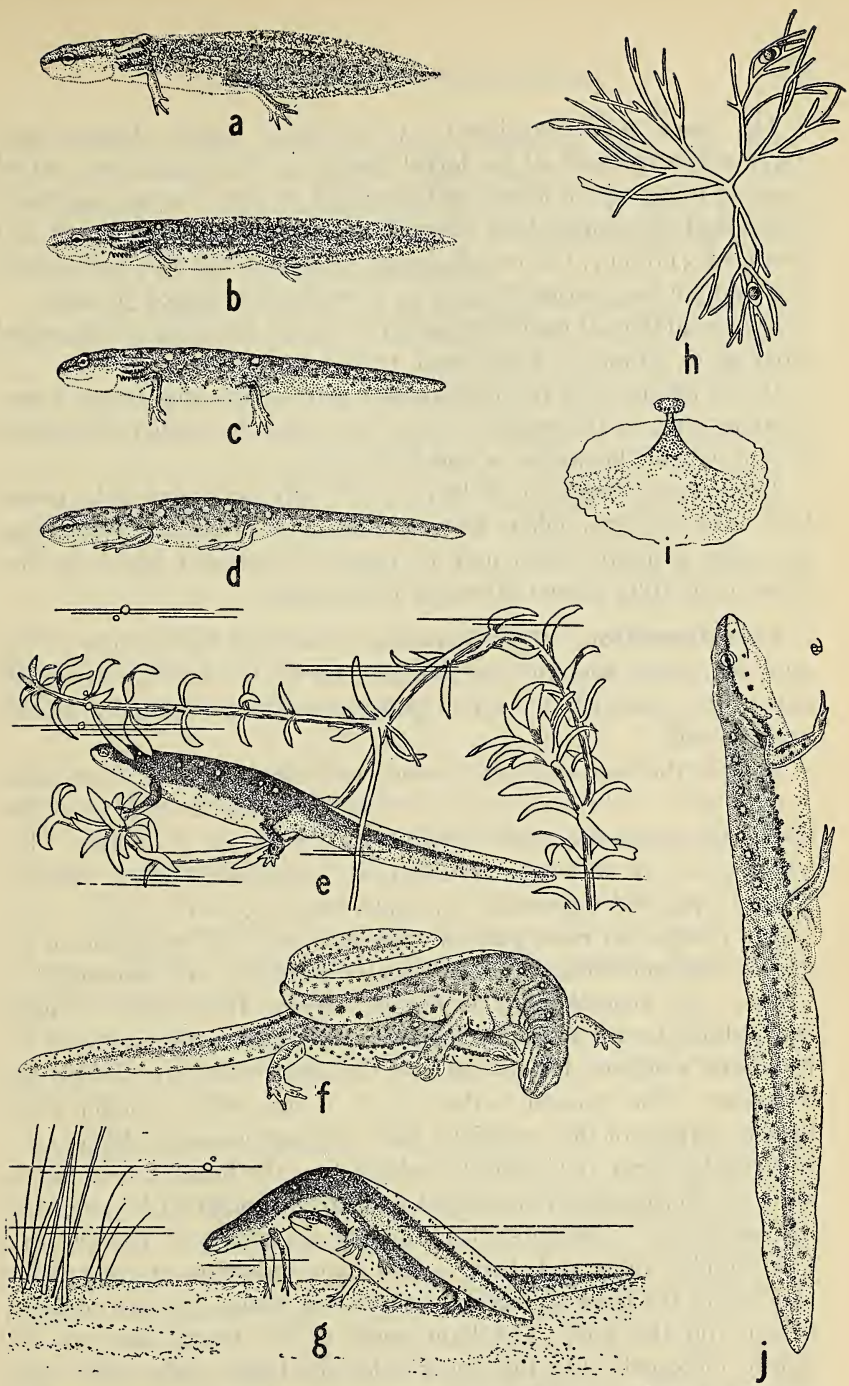


Fig. 16 *Triturus viridescens viridescens.* a. Full-grown larva, East Nassau, N. Y., Aug. 12, 1927. Actual length, 38 mm. b. Larva beginning transformation. Dorsal fin reduced, pale spots appearing. East Nassau, N. Y., Aug. 22, 1927. c. Larva nearing transformation. East Nassau, N. Y., Aug. 22, 1927. d. Recently transformed, same data as above. e. Female newt in position assumed when depositing eggs. f.–g. Courtship positions. h. Eggs among leaves of Hornwort. i. Spermatophore (after Jordan). j. Neotenous newt from pond at Coram, N. Y., June 23, 1928. Actual length, 77 mm.

The same pond furnished 73 additional larvae August 22d. Twenty-five retained all the larval characters fully developed, varied from 29 to 39 mm in length and averaged 35 mm; twenty specimens which had the dorsal keel reduced varied from 31 to 42 mm and averaged 34.8 mm; the remaining 28 specimens had lost both dorsal keel and tail fins, varied from 33 to 40 mm and averaged 36 mm.

Eleven additional transforming larvae taken September 15th varied from 35 to 39 mm and averaged 37.09 mm.

It will be observed from the figures given above that larvae transforming early in the season average only slightly smaller than those coming out of the water in mid-September.

The average length of all larvae with fully developed gills, dorsal keels and tail fins, taken between the dates indicated above, was 35.1 mm, a figure which may be taken to represent fairly the size attained by fully grown larvae at this locality.

Transformation. Transformation is marked by the loss of the gills, the dorsal keel and the tail fins and by the acquisition of pale dull white, yellowish or salmon pink spots which eventually become brilliant red.

In 1927 the first fully transformed individuals on land were taken August 17th. These specimens averaged 36 mm in length. A few additional specimens taken August 22d averaged 36.2 mm. The average of all recently transformed individuals taken between August 17th and September 15, 1927, was 36.7 mm.

The changes in color pattern coincident with the reduction of the dorsal keel and loss of other larval characters, are essentially as follows: the general color is darker varying from light yellowish and reddish brown to pale olive-green; the upper sides between the legs have a definite bluish cast and the lower sides are pinkish and iridescent. The general darker color is apparently brought about by the increase of the superficial black chromatophores. Black spots of irregular form, only slightly indicated on the broad finned larvae, are here conspicuously developed and large enough to be seen with the naked eye. The dorsal keel, lost by absorption, is reduced to a low rounded ridge and there is also some reduction of the tail fins and loss of the large blotches of yellow and orange pigment formerly present on the fins. The light spots of the lateral line are still faintly indicated. On the upper sides the larger pale spots which mark the position of the red spots of the older specimens are in this stage lightly tinged with yellow, gold, pink or bronze. The gills are also lightly touched with metallic hues on the upper surface

and there is a slight shortening of the filaments. The belly is still pink and silvery but here and there are a few scattered black chromatophores. Rarely individuals will retain the reduced dorsal keel until the spots on the upper sides have become definitely pinkish and partially surrounded by a black ring.

With the continued growth and development, the general color gradually darkens and becomes essentially that of the aquatic adult. The color at this stage in various individuals varies from yellowish brown, light olive-brown and light olive-green to pale reddish brown. The light spots on the sides may be pink, salmon, or light orange-red. with or without incomplete black rings. The dorsal keel is lost and that of the tail reduced or entirely absorbed. In many specimens there is a noticable reduction in the length of the gills.

There is an increase in the number of small black chromatophores and the larger dark spots are deep black and quite conspicuous. The belly is more definitely yellow, though still with a silvery tinge, and flecked with scattered black chromatophores, particularly along the midline. With the further reduction of the gills the newts begin to leave the ponds and may be found along the margins hiding beneath rubbish. In a few days they may travel considerable distances and be quite widely dispersed.

The young newts on land are still darker than they were a few days before in water. All vestiges of the gills may be lost or rudiments retained for ten days or longer. The general color now varies from yellowish brown to dull reddish brown and the spots on the sides are definitely pinkish and at least partially black ringed. The belly varies from bright yellow to orange-yellow.

The red of the typical eft is gradually acquired on land and the individuals transforming early in the season may have their full color by September 15th.

Development to maturity. As pointed out in the paragraph dealing with the size attained by efts, the length of the sojourn on land varies considerably in different localities and even among individuals at the same locality. The measurements of 118 specimens taken in migration indicate that sexual maturity *may* be attained at the end of the second year on land; many individuals, however, do not return to the water until the end of the third year. These statements refer only to the newt of the inland districts where the life history includes the well-defined land stage. The newt of the coastal plain is discussed elsewhere.

Habits

General. The aquatic adults are more or less active throughout the day and may be found swimming leisurely around in the open water, their forelegs held to the sides, or crawling slowly over the bottom of pools or quiet streams. To avoid the direct glare of the sun, they sometimes congregate in small patches of aquatic plants where their colors and markings blend with the lights and shadows and render them well-nigh invisible.

In permanent ponds the newt may continue more or less active all winter. There are times, however, both in the winter and during colder periods of spring and fall when the entire population of a pond will disappear, presumably burrowing in the mud of the bottom. When temporary ponds and pools dry up in late fall many individuals are forced to bury themselves and go into hibernation.

The land stage newt or eft is frequently found during the daylight hours but avoids the bright sun. It is perhaps most commonly observed after warm showers when it is often possible to collect great numbers. During dry weather it hides beneath logs and stones or in the moist humus of the forest floor.

Food. The chief food of the adults consists of worms, insects of various kinds and their larvae, small amphibians, leeches, small crustaceans, mollusks both shell bearing and naked, and more rarely small fish, such as sticklebacks. The eggs of various amphibians were taken, and at Heart Lake, Adirondack Lodge, N. Y., I found newts gorging themselves on the eggs of the mink frog, *Rana septentrionalis*. The food of the red eft is composed of insects, spiders, mites, worms, mollusks and other small forms of animal life found in terrestrial situations. Larvae have been known to eat Entomostraca, small worms, insect larvae and minute mollusks. Additional notes on the food of the newt are given by Smallwood (1928, p. 96).

Hamilton (1932, p. 84) writes of the food and feeding habits of the newt as follows:

> The food and feeding habits of an aquatic vertebrate, such as the newt, change as quickly as a group of organisms reach their peak, pass and are replaced by another set. During April, in temporary pools, newts may be gorged with Eubranchipus one week and in the next mosquito larvae may have taken the place of the fairy shrimp. . . .
>
> During late March, newts were observed on several occasions feeding on the eggs of *Ambystoma maculatum*. Stomach analysis shows this to be the important food at this season, but Cyclops,

Asellus and numerus midge larvae were also found. Three weeks later, in mid-April, the fairy shrimp, Eubranchipus, took first place while midges, small snails and cast skins of the newts were eaten avidly. Early in May the small Diaptomus and the mosquito larvae, Aedes, were consumed greedily, together with eggs of *Rana sylvatica,* many cladocerans and daphnids.

In May and early June the newts were observed feeding on leeches, midge larvae, caddis worms and small water beetles. They appeared to disregard entirely the multitudes of small immature Corixa, Notonecta, Odonata and hydrachnids that swarmed in the water at the time. Numerous stomach analyses proved this to be correct. Many of the pools under observation dried up during the midsummer, but while some dampness remained in the vegetation on the bottom, the newts were to be found concentrated in large numbers. Examinations of the stomachs of a considerable number at this time found them to be feeding upon thrips, mites, spiders and small beetles as well as an occasional snail.

In small pools about the lake, newts were observed courting and feeding the second week of October. The food at this time was snails, scuds, *Asellus,* caddis worms and an occasional small minnow. The last newts were secured on November 20. At this time the water was quite cool, but all examined had eaten well. Small snails, water beetle larvae *(Haliplus)* and many scuds were the dominating food items at this period. At this late date the courting act was frequently observed.

Matheson and Hinman (1929, p. 188) call attention to the newt as an efficient destroyer of mosquito larvae.

Surface (1913, p. 109) examined 233 specimens of which 121 contained food. Surface believed that snails formed a large part of the food but included among other items beetles, flies, ants and vegetable matter.

The winter habits and food consumption of adult newts throughout the year have been studied by Morgan and Grierson (1932, p. 54–62). These writers found adult newts semiactive and feeding all winter in ponds and spring-fed streams in Massachusetts. At times, groups of 20 to 40 individuals were found beneath flat stones on the stream bottom or in Chara beds but the animals were not completely dormant and had apparently been feeding.

Insects, found to be the most important item in the diet of the newt, were eaten every month of the year. From January through April they were practically the only food taken. Other food organisms included mollusks, crustaceans, larval newts and plant fragments.

Respiration. It has been clearly demonstrated by Gage (1891*a,* p. 1099) that in the early larva respiration is wholly of the aquatic

type. As the lungs develop respiration gradually changes to the mixed type, partly aquatic and partly aerial. At transformation, if the larva leaves the water, respiration becomes wholly aerial. Physical changes in the structure of the oral epithelium accompany the changes in habits and habitat. In the aquatic larva and adult, the epithelium of the mouth is nonciliated, while in those individuals having complete aerial respiration, the mouth cavity is lined with ciliated epithelium which is continuous with that of the esophagus.

Habitat

The aquatic adults are found in lakes, ponds, pools, ditches and quiet reaches of streams. They are perhaps most abundant where there is a fair amount of vegetation present but they also occur over clear, rocky and sandy bottoms where plant growth is absent. Temporary pools often harbor them in numbers during the breeding season and as long after as there is water present. Lakes or ponds surrounded by deciduous or mixed forests are likely to have a greater newt population than similar waters in evergreen woods. Ponds and pools a considerable distance from forests of any kind are sometimes occupied, the newts making long migrations to and from suitable terrestrial covers.

The efts are found in both mixed and deciduous forests that are either in second growth or virgin condition. Cut over brush lands also support them if the shelter is at all suitable. We have taken them on Long Island and elsewhere only a few feet above sea level and at an elevation of 4000 feet in the Adirondacks.

Summary of life history. It will be convenient at this point to summarize briefly the chief points in the life history of the typical newt so that a comparison may be made with newts from localities where there is often some deviation from the normal sequence of events.

The great majority of newts of the inland, to consider them apart from those of Long Island and certain coastal plain areas, hatch from eggs deposited in the spring and transform in August or September, losing gills and tail fins and acquiring a reddish color, rough skin and rounded tail. After a sojourn on land which may be extended to three years, they return to the water, developing on the way, or after reaching the water, the familiar characters of the adult.

On Long Island, in the vicinity of New York City, near Woods Hole, Mass., and presumably elsewhere in the coastal plain, the

details of the life history, so far as they are known, differ somewhat from those of the majority of inland forms.

The Long Island newt. Pike (1886, p. 25) was perhaps the first to call attention to the reddish-brown coloration of the red land-stage newts from the vicinity of Brooklyn and to contrast this coloration with that of efts from other localities. Sherwood (1895, p. 36) studied the newt in the vicinity of New York City and Mount Vernon, N. Y., and commentated on the scarcity of the "miniatus" form, the red eft, in these localities. He also suggested the possibility, later confirmed by Noble (1926), that in certain localities transformation to a land stage does not take place and that the whole period of growth may be aquatic. Sherwood also mentioned (*ibid.*, p. 37) specimens 2¼ to 3¼ inches long which had retained the gills thus adding to the evidence earlier produced by Gage (1891*a*, p. 1094), who recorded a large branchiate larva from a fresh water pond near Woods Hole, and of Hay (1891, p. 147) who examined larvae 2¾″ long with gill rudiments from Jersey City, N. J.

The most detailed account of the Long Island newt is by Noble (1926). This paper is mainly a criticism of some of the conclusions reached by P. H. Pope in his, Life History of the Common Water-Newt, *Notophthalmus viridescens* (1924). Some of Noble's statements and conclusions are open to serious question. On page 11 he writes: "The Newt does not tolerate typical coastal plain ponds. Its distribution on Long Island is limited to the region of the terminal moraine." These statements stand in need of correction. Newts have been collected in the coastal plain ponds of Long Island and elsewhere and they are not limited to the region of the terminal moraine. At the eastern end of the island, there are many specimens from localities north of the terminal moraine, they are common near Yaphank in the outwash plain of the moraine and there are specimens in the Philadelphia Academy from Rockaway Beach, Queens county (Fowler and Dunn, 1917, p. 27). Noble also writes, page 11, "The Long Island Newts do not go through a terrestrial red eft stage, but pass one spring and summer as dark reddish or yellowish forms in the water before reaching sexual maturity." The first part of this statement is incorrect and the second part needs to be qualified. The red eft does occur on Long Island where it has been known since 1886 when Pike collected many specimens at Brooklyn. It occurs less frequently than in most other parts of New York and apparently does not attain the brilliant color of efts from moist upland regions. I have taken the red eft at Syosset,

October 16, 1925, while collecting in company with George P. Engelhardt and Walter Schoonmaker and more recently it has been taken by George Wilmott at Middle Island, April 16, 1932, and at Coram, September 9, 1938. Of the specimen from Syosset, Noble (1929, p. 12) writes: "The specimen which was considered by its discoverers to be a red eft is in all probability an immature reddish newt beginning its hibernation on land. At least this specimen can not be taken as evidence that the red-eft stage occurs on Long Island." Noble's statement that the specimen is, "an immature reddish newt" is perfectly correct. It is also true that the specimen was on land and possesses all the characters of the red eft including the rounded tail, rough skin and other features commonly associated with this stage. Immature red or reddish newts from other parts of the State also pass the winter in hibernation but they are, none the less, red efts. That Long Island newts pass but a single spring and summer as dark reddish or yellowish forms in water before attaining sexual maturity, has not been demonstrated. Some individuals at some localities may attain sexual maturity at the end of the second season in water, their first as transformed individuals, but Noble has not presented evidence in support of this view. On May 30, 1925, Noble, at Victor Edward's pond near Middle Island, collected some sexually immature aquatic newts which varied in length from 42.5 to 66.5 mm in total length (Noble, 1926, p. 3). To anyone who is acquainted with Long Island newts, it is evident that even the smallest of these were hatched the spring of the year before and were something over a year old when taken. Collecting at the same locality on July 9th,[1] Noble took other immatures varying in length from 68.5 to 79 mm. He assumes that following metamorphosis, these specimens had attained their growth in a single spring and summer season. The larger specimens may well have been their second season as metamorphosed individuals; and they were still immature.

I have collected and measured many newts from Long Island and the young of the year in July (at Middle Island where Noble collected his specimens) average only 38 mm in total length. At Cold Spring Harbor a series collected in July vary in length from 17 to 33 mm. Long Island has a somewhat longer growing season than parts of upper New York and newts apparently attain a slightly larger size during the spring and summer season; nevertheless, many

[1] In the text it is indicated that the July 9th specimens were taken the same year as those collected on May 30, 1925, but at the head of the table on p. 4, the date is given as July 9, 1926.

of them transform at a length of about 40 mm and regularly leave the water in the fall. This is true of newts found in the vicinity of Syosset where the general forest cover on the hills surrounding some of the breeding ponds are of a mixed deciduous character. The length of the terrestrial red-eft stage in this locality has not been determined but it apparently extends over a period greater than a single fall and winter. The red eft taken in October was 56 mm in total length. Since Long Island newts at this locality transform at a length of approximately 40 mm, and since little growth takes place during the winter, it is reasonable to assume that specimens of approximately the same size should be found in the breeding ponds in the spring, if they spent but a single fall and winter on land. I have collected many transformed newts in the ponds at Syosset during June and the smallest individual discovered measured 59 mm in total length. At this locality I have never discovered a specimen which had retained rudiments of the gills or open gill slits. In certain Long Island waters, however, notably at Victor Edward's pond near Middle Island (Noble, 1926, p. 1, 3) and in several small ponds near Coram, many newts complete the life cycle in the water and a considerable proportion retain vestiges of the gills. In these localities, except in the immediate vicinity of water, the land is

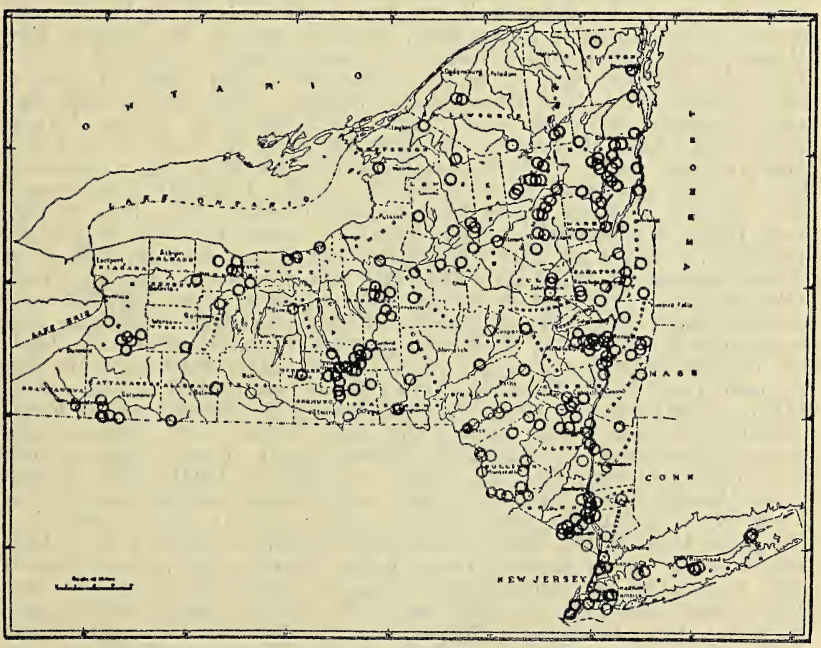


Fig. 17 New York localities for *Triturus viridescens viridescens.*

generally dry and sandy with scrubby growths of pine, oak, birch and cedar and tangles of catbriar (Smilax). Even in such situations red efts have been found though they are by no means abundant.

Range

Northern Ontario and height of land in Quebec, southward through the eastern states to Georgia, westward to Alabama and north to northern Illinois and Wisconsin.

Distribution in New York

General. Throughout the State except on the summits of the higher mountains. On Long Island now mainly restricted to the northern half.

Specific records. ALBANY: *Albany,* May 9, 1835 (Eights, 1836); Apr. 10, 1922, many in Lizard pond; Apr. 16, 1922, several; Apr. 16, 1922, 3♂, N. Y. S. M. No. 9143; Apr. 5, 1923, 1 ad.; Apr. 23, 1923, 1 pair; Apr. 4, 1924, 1♂; Apr. 5, 1924, 1 pair; Apr. 7, 1924, 1♀; Apr. 12, 1924, many in Lizard pond; Apr. 14, 1924, 1♂ 1♀; May 4, 1924, 2 ads., 1 larva; May 7, 1924, many ♀ with eggs, 1 eft in water; Apr. 10, 1926, 2♂; Apr. 13, 1926, 1♂; Apr. 22, 1926, 1♂; *Altamont,* June 13, 1926, 2 ads. (C. Brown); June 2, 1927, 1 eft (Theo. Were); *Aquetuck,* May 4, 1924, ♂ and ♀; *Clarksville,* May 22, 1922, 9 efts; May 8, 1926, 2 ads. (S. C. B. & B. S. B.); June 9, 1926, 1 eft (W. J. S.); *East Berne,* June 18, 1922, 2 efts; *Kenwood,* May 23, 1892, 1 eft (46th Ann. Rep't State Mus. 1893); *New Salem,* Nov. 4, 1922, 1 eft; Apr. 13, 1926, 1 ad.; *Normansville,* Apr. 26, 1922, 1♂, N. Y. S. M. No. 9163; *Ravena,* May 3, 1924, 1 eft; *Selkirk,* Sept. 15, 1924, 1 eft. *Thacher Park,* May 27, 1923, 2 efts; Aug. 3, 1927, 1 eft; Aug. 31, 1927, 15 ads. (S. C. B. & D. Cook); Sept. 3, 1927, 5♂ 4♀ (S. C. B. & A. S. B.); Sept. 13, 1927, 3♂ (S. C. B. & W. J. S.); *Feeney Pond, Thacher Park,* May 8, 1928, many adult specimens, N. Y. S. M. No. 4721 (S. C. B. & W. J. S.); May 28, 1928, many adults, N. Y. S. M. No. 4726 (S. C. B., D. Cook & W. J. S.); May 11, 1928, 5 ads., U. R. No. 1286 (S. C. B. & W. J. S.); *Thompson's lake,* June 20, 1908, 1 ad., N. Y. S. M. No. 90 (F. H. Ward); *Voorheesville,* Nov. 4, 1922, 1 eft, N. Y. S. M. No. 9419; *Warner's lake,* June 17, 1927, 1 eft (Edna & Albert Were). ALLEGANY: 4 ads., U. S. N. M. No. 3800 (Steiner); *Ceres,* 1 eft, (7th Rep't State Cab. 1854); Aug. 30, 1926, 1 eft; *Alfred,* common (F. W. Ross). BROOME: *Binghamton* (G. Bump). *Nanticoke creek,* 1½ mi. west of Union, Aug. 16, 1935, 1 ad. BRONX: *Van Cortland Park,* Apr. (W. T. Davis). CATTARAUGUS: *Allegany State Park,* June 9, 1933, 1 ad., U. R. No. 3120 (S. C. B., H. Chrisp, K. Lagler and C. Zorsch); Oct. 19, 1934, 1 eft, U. R. No. 3437; Blacksnake Mt, Aug. 17, 1926, 1 ad., N. Y. S. M. No. 3136 (Bishop, 1927); July 20, 1931, 2 efts (Homer Jack); Buffalo Camp, Aug. 16, 1926, 1 eft (Bishop, 1927); Ranger trail, Oct. 23, 1937, 3 efts; Butler's run, Aug. 5, 1926, 1 eft (Bishop, 1927); Camp Turner, Aug. 25, 1926, 1 eft (Bishop, 1927); Frecks, Aug. 10, 1926, 1 eft (Bishop, 1927); Aug. 18, 1926, 1 ad. (Bishop, 1927); Aug. 21, 1926, 1 ad. (Bishop, 1927); Aug. 23, 1926, 1 ad. (Bishop, 1927); Aug. 27, 1926, 1 ad., N. Y. S. M. No. 3191 (Bishop, 1927); Oct. 19, 1934, 1 eft, U. R. No. 3437; Pond at Nat. Hist. School, July 11, 1931, 2 larvae, 1 ad. (Homer Jack); Aug. 1931, 4 larvae (Homer Jack); Sept. 21, 1931, 1 ad.; Oct. 10, 1931, 2 ads.; Oct. 10, 1936, sev. ads.; Aug. 27, 1937, 3 ads., U. R. No. 4210; May 7, 1938, many; Oct. 15, 1938, many; Pierce run, Aug. 19, 1937, 10 spec., U. R. No. 4142; Quaker run, Aug. 3, 1922, N. Y. S. M. No. 3333 (Bishop, 1927); Aug. 23, 1923, 6 ads., (Bishop, 1927); Pickup pond, July 7, 1931, 6 larvae (Homer Jack); Stony run, Aug. 12, 1922, 1 eft, R. S. No. 4441

(W. A. Dence); *Steamburg, Red pond,* Aug. 24, 1926, 1 eft, N. Y. S. M. No. 3105. CAYUGA: *North Fair Haven,* Oct. 28, 1923 (F. Harper, mms). CHAUTAUQUA: *Poland Center,* Sept. 12, 1937, sev. efts. CHENANGO: (DeKay, 1842), *Greene,* Apr. 19, 1928, 2 ads., N. Y. S. M. No. 4716–17 (W. Bartlett); May 4, 1928, 2 efts (W. Bartlett); May 26, 1928, 17 efts, N. Y. S. M. No. 4782 (W. Bartlett); *Pharsalia* (G. Bump). CLINTON: *Ellenberg,* July 1922 (M. Baker); *Plattsburg,* common, all stages (G. H. Hudson). COLUMBIA: *Queechy lake,* May 29, 1921, 1 ad., N. Y. S. M. No. 9118 (W. J. S.). CORTLAND: *Cortland,* May 27, 1919, 1 eft; *Chicago bog* near Ithaca, May 17, 1924, 1 pair (F. Harper); Oct. 10, 1933, 2 spec., U. R. No. 3230, 3259 (W. J. Koster); *Gracie,* Beaver brook, May 2, 1934, 1 eft; Solon, Aug. 12, 1935, U. M. No. 78867 (Bailey). DELAWARE: *Stamford,* Apr. 25, 1926, several ♂ (Betty Chrisp); Oct. 10, 1933, 4 spec., U. R. No. 3260 (H. P. Chrisp); July 4, 1935, many ads.; July 1, 1935, 1 ad.; *Corbett,* Je. 27, 1935, abdt. (R. M. Bailey); Sept. 5, 1935, 2 efts; *Downsville,* July 1, 1935, 1 ad.; July 11, 1935, 1 ad.; *Fish's Eddy,* July 5, 1935, 19 ads., U. M. No. 78865 (Bailey); *Pepacton,* July 22, 1935, abdt. DUTCHESS: *Hyde Park,* June 13, 1924, 1 eft (F. Harper); *Lafayetteville,* June 15, 1938 (VanAuken); *Poughquag,* July 12, 1936 (Hall); *Pine Plains,* Aug. 17, 1936. ERIE: *Boston, Colden, Glenwood, Hamburg, Holland, Springville,* 1925 (R. R. Humphrey); *Holland,* Aug. 1–16, 1930, U. R. No. 2121 (E. L. Hilfiker); *Springville,* Sept. 26, 1928, 1 eft (F. J. Holl). ESSEX: (Allen, 1869); *Adirondack Lodge, Heart (Clear) lake,* July 2, 1923, many in lake; July 12, 1923, 2♀; July 24, 1925, many in lake; Aug. 2, 1925, many in lake (F. Harper); Aug. 7, 1925, many in lake (F. Harper); July 24, 1926, 1 ad. (F. Harper); July 28, 1926, adults (F. Harper); Aug. 22, 1928, many ads.; Aug. 2, 1931, many aquatic ads.; *Alder creek,* trib. of Schroon river, Aug. 23, 1932, 6 spec., U. R. No. 3220; *Augur pond,* March 14, 1891, U. R. No. 1336 (G. H. Hudson); *Blue Ridge,* June 20–30 to Sept. 1926 (Weber, 1928); *Boreas Mt, Elk lake & Clear pond,* June 20–30 to Sept. 1926 (Weber, 1928); *Clear pond,* July 16, 1932, 5 spec., U. R. No. 3211; *Chapel pond,* July 21, 1925, 1 ad. (F. Harper); July 20, 1925, 1 ad. (F. Harper); *Crown Point,* M. C. Z. No. 4731–2, 1140(2), 1237 (Dunn, 1918); *Giant Wash Bowl, Chapel Pond pass,* July 19, 1925, 1♀; *Minerva,* May 20, 1920, 3 efts, N. Y. S. M. No. 8690–2 (W. Holes); *Mt Pharoah,* E. of Schroon lake, June to Sept. 1926, common in lakes (Weber, 1928); *between N. Hudson & Underwood,* June to Sept. 1926 (Weber, 1928); *Owl Pate, Mt Johnson pond,* June to Sept. 1926 (Weber, 1928); *Paradox lake, Severance,* June 20–30 to Sept. 1926 (Weber, 1928); *Westport,* U. S. N. M. No. 3492 (Yarrow, 1882); 8 spec., U. S. N. M. No. 3826, 3793 (S. F. Baird); Aug. 1922 (Greene, 1923); Aug. 16, 1932, 2 spec., U. R. No. 3212. FRANKLIN: *Axton,* Dawson pond, May 6, 1903 (Evermann, 1918). FULTON: *Bleeker Center,* July 23, 1932, 1 ad.; *Johnstown,* 1 eft (Rep't N. Y. S. M. 1909); *Mountain lake,* 1908, 1 ad., N. Y. S. M. No. 93 (C. P. A.). GENESEE: *Bergen swamp,* June 8, 1929, several ads. and efts, U. R. No. 1065; June 25, 1929, many ads. and 1 eft (S. C. B. and R. Hart); Oct. 12, 1929, several efts (S. C. B. and C. Bentley); May 28, 1933, several ads. and efts, U. R. No. 2748; May 25, 1938, ads. GREENE: *Coxsackie,* 1851, 1 ad., 1 eft (Baird, 1852); *Elka Park,* June to Aug. 1, 1913, 15 ads., R. S. No. 318; Aug. 10, 1915, 1 male, R. S. No. 323; *Haines creek* (Fowler and Dunn, 1917); *Kaaterskill lake,* Aug. 4–Sept. 14, 1896 (Mearns, 1898); *Lanesville,* July 1922, A. M. No. 17097; *Tannersville,* Aug. 11, 1916, 2 ads., A. M. N. H. No. 5055, 5058; *Urlton,* June 19, 1936 (Bailey and Lagler); 4 mi. west of Urlton, June 23, 1936 (Bailey and Lagler). HAMILTON: (Baird, 1850); *Blue Mt lake,* and *Pine pond outlet,* July 7, 1933, 3 spec., U. R. No. 3222, 3223; *Clear (Eaton) pond,* June 19, 1933; June 21–26, 1933, 4 spec., U. R. No. 3209, 3210; *Eagle lake,* June 29, 1933, 1 spec., U. R. No. 3221; *Eighth lake,* Aug. 1925 (R. R. Humphrey); *Fawn lake,* near Speculator, Aug. 29, 1932, 97 spec., U. R. No. 2671 (Leo Murray); outlet of *Lewey lake,* Aug. 30, 1932, 6 spec., U. R. No. 3231; *Lake Pleasant* (DeKay, 1842); *Long lake,* June 22, 24, 1933, 5 spec., U. R. No. 3213, 3214; *Mason lake,* Aug. 30, 1932, 7 spec., U. R. No. 3219; *Miami river,* Aug. 30, 1932, 2 ads., U. R. No. 3228; *Piseco,* 4 spec., U. S. N. M.

No. 36975–78; *Snowy Mt, Indian lake,* Sept. 4, 1927, 1 eft, alt. 3903 feet, N. Y. S. M. No. 4046 (J. Heller); *Indian lake,* July 17, 1925 (F. Harper, mms); *Rock river,* near mouth, Sept. 1, 1932 (L. Murray); *Seventh lake,* Fulton Chain, June 14, 1931, U. R. No. 2032 (J. R. Greeley); June 17, 1931, elev. 1786, 7 spec., U. R. No. 2019; *Utowana lake* outlet, July 14, 1933, 10 spec., U. R. No. 3227. HERKIMER: *Wilmurt,* Aug. 3, 1902, N. Y. S. M. No. 32 (F. C. Paulmier). JEFFERSON: *Sackets Harbor,* Bedford creek, June 30, 1931, several ads.; *Somerville,* M. C. Z. No. 167, 189 (2) (R. Hough); (Dunn, 1918). KINGS: *Brooklyn* (Dunn, 1918); 1 ad., M. C. Z. No. 230; *Fort Hamilton* (Pike 1886). LEWIS: *Black creek* (trib. Beaver river), Aug. 11, 1931, 2 ads.; (½ mi. below source) Aug. 11, 1931, 2 ads., U. R. No. 2024; *Jerden Falls,* Aug. 7, 1931, 6 larvae; *Michigan Mills,* Aug. 24, 1927, 5 ads., R. S. No. 4262F (W. A. Dence). LIVINGSTON: *Avon,* Apr. 13, 1929, 4 ads. in water (W. Pierson); Big woods, Avon (Pond 1), Apr. 2, 1929, 3♂, 1♀ (W. Pierson); Oct. 4, 1930, 35 specimens under logs and stones of pond completely dried up (W. Pierson). MADISON: *Oneida,* Oct. 30, 1924, 1 ad. (H. D. House); *Peterboro,* 1 ad., U. S. N. M. No. 28302. MONROE: (Wright and Moesel, 1919); *Fairport,* Oct. 20, 1929, U. R. No. 1338 (R. Hart); *Float bridge,* Apr. 11, 1930, 1 female; *Mendon ponds,* Apr. 29, 1930, 1 eft (P. R. Needham); Oct. 9, 1930, U. R. No. 1224 (E. A. Maynard); May 5, 1931, 1 ad. male, 1 eft (P. R. Needham); May 5, 1932, 12 spec. (R. Redman); Apr. 13, 1933, many, U. R. No. 3121 (E. A. Maynard); Wing's woods, *Mendon,* Aug. 30, 1931, 1 spec., U. R. No. 3229 (A. Wing); *Parma,* Mar. 19, 1929, U. R. No. 2229 (E. L. Hilfiker); Mar. 29, 1929, U. R. No. 2243 (E. L. Hilfiker); Apr. 3, 1929, U. R. No. 2247 (E. L. Hilfiker); July 1931, U. R. No. 2227 (E. L. Hilfiker); Powder Mill Park, Apr. 12–14, 1937, many ads.; *Rochester,* 1 ad., U. S. N. M. No. 64152 (H. E. Hubert); Durand-Eastman Park, Apr. 19, 1929, 1 eft. NASSAU: *Syosset,* May 31, 1915, many in ponds (Engelhardt, 1916*a*); Nov. 8, 1921, several in hibernation (Noble, 1926); Oct. 16, 1925, 1 eft, N. Y. S. M. No. 1969 (S. C. B., W. J. S., and G. P. E.); (Noble, 1929); June 22, 1928, 26 males, 13 females, 4 juv. (S. C. B. and J. A. Weber); June 25, 1928, 8 males, 7 females; Glen Cove, July 11, 1938, 1 neoteinic, U. R. No. 4449 (C. W. Greene). ONEIDA: (Dunn, 1928); *Boonville,* many in pond (L. Karleskind); *Remsen,* June 5, 1916, many (F. Harper); *Rome,* 19 specimens, M. C. Z. No. 184 (J. L. Lincoln); *Stittville,* May 1, 1916, several in ditch (F. Harper); *White lake,* July 1902, 5 efts, N. Y. S. M. No. 33 (Eckel); *White lake outlet,* June 15, 1931, several ads.; ⅜ mi. below lake, Aug. 13, 1931; ¼ mi. E. of *Woodville Station,* Aug. 18, 1931, several. ONONDAGA: *Jamesville, Manlius, Onondaga Valley, Pompey, Syracuse, Tulley* (Britcher, 1903); Labrador pond, *Fabius,* June 17, 1917, 2 ad. males, R. S. No. 15, 25 (A. G. Whitney); *Jamesville, Green lake,* May 8, 1915, 8 pairs, R. S. No. 13*a* (C. C. Adams); May 15, 1915, 1 ad., R. S. No. 54; *Syracuse,* May 14, 1918, 1 eft, R. S. No. 668 (W. C. Wessell); many (J. R. Slater). ONTARIO: *Geneva,* very common (E. H. Eaton). ORANGE: *Arden, Echo lake,* Aug. 11, 1918, 9 ads., R. S. No. 2134 (Adams and Hankinson); Aug. 19, 1918, 1 ad., R. S. No. 2135 (Adams and Hankinson); Aug. 14, 1936, abdt.; *Cranberry pond,* Aug. 25, 1910, 41 spec., U. S. N. M. No. 42717–57 (E. A. Mearns); *Cornwall,* Apr. 7, 1923, 1 ad. (F. Harper); June 15, 1924, 4 efts (F. Harper); June 22, 1924, several efts (F. Harper); June 14, 1925, 24 efts (F. Harper); June 21, 1925, dozens of efts in road following shower (F. Harper); June 23, 1925, several (F. Harper); June 30, 1925, 1 eft (F. Harper); July 1, 1925, 2 efts (F. Harper); July 2, 1925, very abundant (F. Harper); July 5, 1925, efts common on dry hillsides (F. Harper); *Cuddebackville,* July 3, 1935, ads., abdt., *Greenwood lake,* 1893, 16 spec., A. M. N. H. No. 3612–18; *Highland Falls,* July 14, 1910, 1 spec., U. S. N. M. No. 42787 (E. A. Mearns); 4 ads., A. M. N. H. No. 2567–70; 53 spec., U. S. N. M. No. 23238–90 (E. A. Mearns); *Morgan's pond,* July 19, 1910, 1 spec. U. S. N. M. No. 42786 (E. A. Mearns); *Palisades Interstate Park,* near Arden, Aug. 13–29, 1937, 1082 efts, (M. B.); Sept. 18–20, 1938, 413 efts (M. B.); Car pond, Aug. 26, 1918, 16 ads., R. S. No. 2167–8, 2170, 2172 (Adams and Hankinson); Aug. 27, 1918, 20 ads., R. S. No. 2177, 2179–80

(Adams and Hankinson); July 14, 1919, 5 ads., R. S. No. 2299 (Fletcher and Merrill); Cedar pond, July 5, 1919, 5 ads., R. S. No. 2266 (Adams and Hankinson); Aug. 8, 1918, 3 ads., R. S. No. 2101–02 (Adams and Hankinson); Aug. 9, 1918, 1 ad., R. S. No. 2103 (Adams and Hankinson); Aug. 10, 1918, 3 ads., 1 eft, R. S. No. 2107–8 (Adams and Hankinson); Aug. 12, 1918, 2 ads., R. S. No. 2111–12 (Adams and Hankinson); Aug. 13, 1918, 2 ads., R. S. No. 2116, 2119 (Adams and Hankinson); Aug. 16, 1918, 15 ads., R. S. No. 2126–27, 2129 (Adams and Hankinson); July 15, 1919, 9 ads., R. S. No. 2403 (Hankinson); Howells, Aug. 4, 1936, 1 larva, (Hall & Stone); Island pond, Aug. 19, 1918, 4 ads., R. S. No. 2136 (Adams and Hankinson); Kanohwahke lake, Aug. 22, 1918, 2 males, R. S. No. 2145, 2147 (Adams and Hankinson); Aug. 23, 1918, 8 ads., R. S. No. 2150–52 (Adams and Hankinson); July–Aug. 1923, 2 ads., 12 yg., A. M. N. H. No. 24215–17 (Myers, 1930); Little Long pond, Aug. 23, 1918, 1 ad., R. S. No. 2153 (Adams and Hankinson); Aug. 28, 1918, 1 ad., R. S. No. 2182 (A. E. Fivaz); between Little Long pond and Island pond, July 7, 1919, 17 efts, R. S. No. 2273 (W. Merrell); Popolopen creek, June 30, 1919, 5 ads., R. S. No. 2247, 2249 (Adams and Hankinson); *Port Jervis,* June 20, 1935, 3 ads. U. M. No. 78870); Queensboro brook, July 11, 1919, 1 ad., R. S. No. 2282 (Adams and Hankinson); *Roe pond,* July 1, 1910, 1 spec., U. S. N. M. No. 42785 (E. A. Mearns); *Southfields,* Aug. 16, 1936, abdt. (R. M. Bailey); *Storm King mountain,* June 18, 1924, 1 eft (F. Harper); *Sutherland pond,* Sept. 2, 1910, 23 spec., U. S. N. M. No. 42762–84; *Tuxedo,* Aug. 11, 1926 (P. Schiffer); *West Point,* ads. and yg., 1879, M. C. Z. No. 5901–15; U. S. N. M. No. 3793, 5 efts (Yarrow, 1882; Cope, 1889). OSWEGO: *Frenchman's Island, Oneida lake,* July 8, 1916, 1 ad., R. S. No. 520 (Hankinson); July 11, 1916, ads. in water, R. S. No. 541 (Hankinson). OTSEGO: *Oneonta,* May 8, 1911, 10 ads., A. M. N. H. No. 1557–66 (Florence Matteson); 1 mi. south of *Edmeston,* Sept. 4, 1935, ads. U. M. No. 78872; 3 mi. east of *Welles,* Aug. 1935, 4 ads. PUTNAM: *Anthony's Nose* (DeKay, 1842); *Carmel,* May 23, 1926, several efts; *Garrison,* Nov. 1884 (Cope, 1889); three spec., U. S. N. M. No. 13,424 (Theodore Roosevelt); *Oscawana lake,* near Cold Spring, July 16, 1936, (R. W. Odell). QUEENS: Nov. 6, 1921, 4 ads. (Noble, 1926); *Jamaica,* Mar. 24, 1919, 2 efts A. M. N. H. No. 6493–4 (H. Boyle); *Richmond Hill,* Apr. 20, 1895, 5 ads., A. M. N. H. No. 3734–8 (E. Smith); *Rockaway beach* (Fowler and Dunn, 1917). The specimens from Jamaica and Richmond Hill are presumably those to which reference is made by Noble, 1926. RENSSELAER: *Dyking pond, Berlin,* June 13, 1926, many in lake (W. J. S.); *East Nassau,* Aug. 12, 1927, 26 larvae, 4 recently transformed, N. Y. S. M. No. 3932–3 (S. C. B. and W. J. S.); Aug 17, 1927, 1 yg., N. Y. S. M. No. 4049; Aug. 22, 1927, 88 mature larvae, N. Y. S. M. No. 3938–9 (S. C. B. and W. J. S.); Aug. 22, 1927, 1 ad., N. Y. S. M. No. 3975 (S. C. B. and W. J. S.); Aug. 22, 1927, N. Y. S. M. No. 4048 (S. C. B. and W. J. S.); Aug. 22, 1927, 3 specimens on land migrating to water, N. Y. S. M. No. 4050–52 (S. C. B. and W. J. S.); Aug. 22, 1927, 1 yg., N. Y. S. M. No. 4087 (S. C. B. and W. J. S.); Sept. 7, 1927, 4 larvae, 10 transforming; Sept. 15, 1927, 1 ad. ♂ in water, 1 specimen on land, N. Y. S. M. No. 4048, 4085; Sept. 15, 1927, 11 yg., 1 ad. ♂, N. Y. S. M. No. 4086 (S. C. B. and W. J. S.); Sept. 15, 1927, on land just transformed, N. Y. S. M. No. 4089; Sept. 15, 1927, 1 ad. and several transforming yg.; Apr. 4, 1928, many in pond (W. J. S.); May 1, 1928, 155♂, 23♀ in pond (W. J. S.); May 1, 1928, many ads., N. Y. S. M. No. 4720 (W. J. S.); May 1, 1928, N. Y. S. M. No. 4723–5 (W. J. S.); May 1, 1928, many spec., U. R. No. 3122 (W. J. S.); May 13, 1928, 13 spec. in pond, N. Y. S. M. No. 4722 (S. C. B. and W. J. S.); Cement pond, Aug. 17, 1927, 36 larvae (S. C. B. and W. J. S.); Aug. 17, 1927, 1 recently transformed on land (S. C. B. and W. J. S.); Sphagnum bog, Aug. 17, 1927, 35 spec. in migration, N. Y. S. M. No. 3958–73, 3976–95 (S. C. B. and W. J. S.); Aug. 22, 1927, 13 spec. in migration to pond, 3 just transformed (S. C. B. and W. J. S.); Sept. 7, 1927, 26 spec. on land in migration to pond (S. C. B. and W. J. S.); Sept. 15, 1927, 2 spec. (S. C. B. and W. J. S.); May 1, 1928, 18♂, 27♀ (W. J. S.); May 10, 1928, 3♂, 1♀ returning to pond (S. C. B. and W. J. S.); *Long pond,* Sept. 7, 1927,

19 aquatic ads., N. Y. S. M. No. 4063–4081 (S. C. B. and W. J. S.); *Mt Rafinesque,* June 6, 1926, 1 eft (C. Brown); *Round pond,* Sept. 7, 1927, aquatic ads. (W. J. S.); *Schodack,* Apr. 22, 1922, 1 eft, N. Y. S. M. No. 9150. RICHMOND: *Staten Island* (Davis, 1884); aquatic ads., A. M. N. H. No. 2577–9 (E. Nielson) (Proc. Staten Island Inst. Arts and Sci., 1924); *Moravian cemetery,* 1913, aq. ads. (Wilmott, 1933); *Ocean Terrace,* Apr. 1909, 5 ads. (Wm. T. Davis). ROCKLAND: *Hessian pond,* Aug. 15, 1918, 3 ads., R. S. No. 2120–2122 (Adams and Hankinson). ST LAWRENCE: 3 mi. S. of *De Kalb,* June 5, 1931, 1 ad.; *Indian creek,* 1½ mi. above mouth, June 5, 1931, U. R. No. 2044 (S. C. B. and J. R. G.); *Scott lake,* 1906, U. S. N. M. No. 36970–74. SARATOGA: (Dunn, 1918); 1 eft, 1886, M. C. Z. No. 2105; *Galway,* Apr. 29, 1924, 1 pr. (G. Matiske); *Glens Falls,* June 30, 1932, U. R. No. 2553; outlet of *Lonely lake,* June 8, 1932, 1♂, U. R. No. 2554; Glowegee creek, *North Galway,* July 25, 1932, 2 spec., U. R. No. 3218; *Round pond,* May 13, 1925 (W. J. S.). SCHOHARIE: near *Coblesskill,* July 29, 1919, 1 ad. SCHUYLER: *Watkins Glen,* June 28, 1931, U. R. No. 1463 (H. Halloway). STEUBEN: *Cameron Mills,* July 9, 1937, 1 ad.; *Addison,* July 1, 1937, 3 ads., U. R. No. 4129; *Canisteo* R. 1 mi. W. of Addison, 2 ads., U. R. No. 4161. SUFFOLK: *Cold Spring Harbor,* July 26, 1933, larvae (P. R. Needham); *Coram,* June 23, 1928, 44 spec. (S. C. B. and J. A. Weber); Sept. 9, 1938, Red eft (G. B. Wilmott). *East Setauket,* Oct. 1922 (H. Haupt jr); (Noble, 1926); *Greenport,* July 2, 1933, 1 ad., 2 juv., 1 larva (R. Latham); *Middle Island,* July 8, 1923, many larvae, A. M. N. H. No. 18681 (G. K. Noble); May 30, 1925 and July 9, 1925, 88 spec. (Noble, 1926); June 1925, 11 ads.; July 9, 1925, aquatic ad. (G. K. Noble); Apr. 16, 1932, 1 red eft (Wilmott); July 31, 1938, abdt.; Aug. 10, 1938, abdt.; *Riverhead,* July 26, 1938, 1 larva, U. R. No. 4463; *Yaphank,* July 9, 1925, many aquatic ads., A. M. N. H. No. 24226–30. SULLIVAN: (W. L. Sherwood, 1895; Dunn, 1918); 2 yg., M. C. Z. No. 1145 (N. S. Shaler); Aug. 12, 5 spec., U. S. N. M. No. 49617–21 (E. J. Brown); 20 spec., M. C. Z. No. 1141 (L. Lockwood); *Barryville,* June 20, 1935, ads. abdt.; *Callicoon,* July 28, 1935, 2 efts; *Debruce,* Aug. 24, 1912, 1 eft, A. M. N. H. No. 457; *Fallsburg* (Dunn, 1918); M. C. Z. No. 4315–16 (S. Lockwood); ad. and yg., A. M. N. H. No. 3619–26 (E. Smith); *Hankins,* Sept. 5, 1935, efts in migration; *Jeffersonville,* 2½ mi. E., June 21, 1935, U. M. No. 78866 (Bailey); *Mongaup,* June 20, 1935, abdt.; *Monticello,* June 20, 1935, U. M. No. 78871 (Bailey); *Narrowsburg,* June 21, 1935, 1 ad.; Pond Eddy, June 20, 1935, abdt.; *Oakland Valley,* 1922, 1 ad., A. M. N. H. No. 14998 (J. A. Weber). TIOGA: (Yarrow, 1882; Cope, 1889); U. S. N. M. No. 3808, 3830; *Barton,* July 22, 1935, U. M. No. 78868 (Bailey); *Berkshire* (Dunn, 1918); M. C. Z. No. 177207(2) (A. Mayor); *North Spencer,* Sept. 24, 1924, 1♀ (F. Harper); *Wilseyville,* Oct. 17, 1923, several (F. Harper); Oct. 22, 1924, 1 ad. (F. Harper); July 24, 1935, abdt. (Bailey). TOMPKINS: *Dryden,* May 25, 1924 (F. Harper); *Ellis Mt.* and *Ringwood,* Apr. 16, 1922 (F. Harper); *Enfield falls,* Apr. 11, 1914, C. U. (F. Harper); Apr. 1, 1917, 2 ads. (J. D. Corrington); *Fall creek,* Apr. 21, 1924 (F. Harper); *Forest Home,* Apr. 12, 1924, C. U. (D. L. Gamble); *Freeville,* Apr. 1, 1917, C. U.; *Groton,* May 3, 1917, 1 ad. (J. D. Corrington); June 7, 1917, 1 eft (J. D. Corrington); Apr. 3, 1920, C. U.; *Inlet valley,* Mar. 18, 1923, C. U.; *Ithaca* (Gage and Norris, 1891); Oct. 8, 1929, ads. mating (Hamilton); Mar. 29, 1935 (Hamilton); *Bethel Grove,* May 7, 1931 (Hamilton); *Bool's backwater,* Apr. 8, 1915, C. U.; Apr. 13, 1916, C. U.; *Bool's brook,* May 18, 1911, C. U.; *Kline road,* May 14, 1924, 1 eft (F. Harper); *Lick brook,* Feb. 3, 1912, C. U.; *Maplewood, Cayuga lake,* Aug. 29, 1924, several (F. Harper); *McLean bogs,* 1922–1925, efts and ads. (Leffingwell, 1926); May 3, 1925, 2 efts (F. Harper); N. Y. S. M. No. 8595 (A. H. W. and S. C. B.); May 2, 1934, 1 eft; *Michigan Hollow,* Jan. 1910, C. U. (A. A. Allen); Jan. 2, 1911, C. U.; *Renwick,* Feb. 1, 1910, C. U.; Mar. 20, 1913, C. U.; Apr. 17, 1915, C. U.; May 7, 1924, 1 eft (F. Harper); Oct. 8, 1924, 2 ads. (F. Harper); Oct. 15, 1924, several (F. Harper); May 6, 1924, 1 eft (F. Harper); *Ringwood,* Apr. 9, 1922, 1 ad., 1 eft, C. U.; Apr. 8, 1923, 2 efts (S. C. B. and A. H. W.); Apr. 3, 1924, "tremendous

numbers," probably 30,000 in pools (Hamilton); July 29, 1932, larvae ready to transform (Hamilton); *Slaterville,* June 30, 1927, U. R. No. 1203 (P. R. Needham); *Slaughter House pond,* Apr. 28, 1925, 1 eft (F. Harper); *Taughannock Falls,* Oct. 1, 1922, C. U.; *Turkey Hill,* Aug. 8, 1923 (A. H. W. and S. C. B.). ULSTER: *Alder lake,* June 12, 3 spec., U. S. N. M. No. 49776–8 (Bean); *Ashokan,* Aug. 10, 1909, many larvae, A. M. N. H. No. 2159, 2161 (A. L. Treadwell); Aug. 12, 1909, 2 ads. and larvae, A. M. N. H. No. 1887, 2151 (A. L. Treadwell); Aug. 13, 1909, larvae and ads., A. M. N. H. No. 1888, 1889–94, 2154 (A. L. Treadwell); Aug. 14, 1909, many larvae, A. M. N. H. No. 2152, 2161 (A. L. Treadwell); Aug. 17, 1909, 5 ads. on land, A. M. N. H. No. 1886 (A. L. Treadwell); Aug. 18, 1909, ads. A. M. N. H. No. 1882 (A. L. Treadwell); Aug. 21, 1909, 31 ads., A. M. N. H. No. 1881, 1895–1925 (A. L. Treadwell); Aug. 22, 1909, aq. ads., A. M. N. H. No. 1926–29 (Myers); Aug. 24, 1909, 1 ad., A. M. N. H. No. 1930 (A. L. Treadwell); *Hemlock Mt,* June 22, 1918, 1 eft, R. S. No. 2000 (C. C. Adams and P. M. Silloway); *Kingston,* June 29, 1909, 5 ads., A. M. N. H. No. 2173 (L. Barnum); *Lake Katrine,* Oct. 15, 1906, 1 ad., N. Y. S. M. No. 1882 (G. H. Chadwick); *Newpaltz,* Aug. 21, 1936, abdt. (Bailey & Stone); *Olive Bridge,* June 17, 1936 (Bailey & Lagler); *Rifton dam,* Sept. 4, 1923, 1 eft (F. Harper); *Saugerties,* July 2, 1936 (Bailey); *Slide Mt,* 1 spec., U. S. N. M. No. 29196 (C. L. Pollard); *West Shokan,* July 29, 1909, A. M. N. H. No. 1877–78; July 30, 1909, 2 ads., A. M. N. H. No. 1887–80; *Wittenberg,* June 27, 1936; *Woodstock,* May 29, 1916, 2 ads., A. M. N. H. No. 3976–7 (A. K. Berger). WARREN: Outlet of *Friends lake,* upper Hudson drainage, June 11, 1932, 14 spec., U. R. No. 2558; *Garnet lake,* Aug. 21, 1937, (Van Auken); *Schroon lake* at *Pottersville,* Aug. 16, 1932, 2 spec., U. R. No. 3215; *Starbuckville, Schroon river,* Aug. 16, 1932, 14 spec., U. R. No. 3216; Hudson river at *Warrensburg,* Aug. 11, 1932, 1 spec., U. R. No. 3224; Aug. 31, 1932, 1 spec., U. R. No. 3225 (O. Smith); *Wolf pond,* upper Hudson drainage, Aug. 19, 1932, 1 spec., U. R. No. 3226 (W. C. Senning). WASHINGTON: Batten Kill at *Clark's Mills,* June 20, 1932, 1 spec., U. R. No. 3217 (M. A. Farrell); June 28, 1932, U. R. No. 2559; Batten Kill at *East Greenwich,* June 28, 1932 (J. R. G.); *Cossayuna lake,* Aug. 28, 1927, 28 efts (J. Heller); Aug. 28, 1927, 1 eft, N. Y. S. M. No. 4088 (J. Heller); Trout pavillion, *Lake George,* Aug. 16, 1916, 1 ad., (70th Ann. Rep't N. Y. S. Mus., 1918); *Owl Kill,* ½ mi. above mouth, July 1, 1932, 3 spec., U. R. No. 2560 (J. R. Cooper); *Queechy lake,* May 29, 1921, 1 ad., N. Y. S. M. No. 9118 (W. J. S.). WAYNE: (Allen, 1869); *Sodus bay,* 1865, 11 efts, M. C. Z. No. 1153 (J. A. Allen); Oct. 22, 1931, 6 spec., U. R. No. 2555; *Blind Sodus bay,* Apr. 23, 1933, 3 efts; *Sodus* (Dunn, 1918). WESTCHESTER: (Deckert, 1914); *Millwood,* July 25, 1936 (Bailey and Lagler); *Nepera Park,* Apr. 20, 1919, 1 eft, A. M. N. H. No. 6393 (G. K. Noble and K. P. Schmidt); *Peekskill,* July 1925, 1 eft (Mansfield); *Mt Vernon* (Sherwood, 1895). WYOMING: *Letchworth Park,* May 18, 1932, 3 spec., U. R. No. 2480.

Records too indefinite in character to be included under counties: "Common in New York State" (Rafinesque, 1820); "Met in every part of the state" (DeKay, 1842); "General in ponds and lakes" (Ditmars, 1905); "Very common in ponds everywhere" (Eckel and Paulmier, 1902); *New York* (Allen, 1869; Yarrow, 1882; Boulenger, 1882; Cope, 1889); *New York,* May 2, 1883, aq. ads., A. M. N. H. No. 1982–88 (E. A. Mearns); *Adirondacks* (Fowler and Dunn, 1917); *Catskill Mts,* 1880–1882 (Bicknell, 1882); (Fowler and Dunn, 1917); 1 spec.. U. S. N. M. No. 23176 (E. A. Mearns); *Cayuga Lake basin* (Reed and Wright, 1909); 1925–1932 (Hamilton, 1932); *Hudson highlands* (Mearns, 1898); *Lake Champlain* (Rafinesque, 1820); *Lake Champlain* and *Northern New York* (Baird, 1850); *Lake George* (Rafinesque, 1820); 8 spec. (46th Ann. Rep't N. Y. S. M., 1893); *Harlem* and *Long Island* (Rafinesque, 1820); *Long Island* (Baird, 1850); 1870, larvae and ads., A. M. N. H. No. 2148, 1989, 2037–60 (N. Pike); 1885, larvae and ads., A. M. N. H. No. 2736–54, 2011–36 (N. Pike); aq. ads., A. M. N. H. No. 1950–81; 1 ad., U. S. N. M. No. 38518 (E. A. Mearns); numerous on Long Island from Brooklyn to Greenport (Pike, 1886); *Ramapo mts,* July 27, 1911, 1 eft (W. T. Davis); *Seneca lake,* 1899, 7 spec., U. S. N. M. No. 36006.

Condensed Bibliography

Life history and habits. Bishop, 1927, p. 39–42 (*Triturus viridescens viridescens*); Brimley, 1921*a*, p. 31–32 (*Notophthalmus viridescens*); Dunn, 1930, p. 3 (*Triturus viridescens viridescens*); Gage, 1891*a*, p. 1084–1110 (*Diemyctylus viridescens*); Hamilton, 1932, p. 84 (*Triturus viridescens viridescens*); Jordan, 1891, p. 263–70 (*Diemyctylus viridescens*); Jordan, 1893, p. 269–366; Monks, 1880, p. 371–74; Noble, 1926, p. 1–11 (*Triturus viridescens*); Noble, 1929, p. 1–22; Pike, 1886, p. 17–25 (*Diemyctylus viridescens* and *D. miniatus*); Pope, 1924, p. 305–68 (*Notophthalmus viridescens*); Pope, 1928, p. 61–72 (*Triturus viridescens*); Sherwood, 1895, p. 35 (*Diemyctylus viridescens*).

Distribution in New York. Allen, 1869, p. 199 (*Diemyctylus miniatus, D. viridescens*); Baird, 1850, p. 288 (*Salamandra coccinea*); Baird, 1852, p. 21 (*Notophthalmus miniatus*); Bicknell, 1882, p. 124 (*Diemyctylus mineatus*); Bishop, 1923, p. 64 (*Notophthalmus viridescens viridescens*); Bishop, 1927, p. 39 (*Triturus viridescens viridescens*); Britcher, 1903, p. 121 (*Diemyctilus viridescens* and var. *miniatus*); Burt, 1931, p. 199 (*Triturus viridescens viridescens*); Cope, 1889, p. 212 (*Diemyctylus viridescens miniatus* and p. 213 *D.* var. *viridescens*); Davis, 1884, p. 13 (*Diemyctylus viridescens* and *D. miniatus*); Deckert, 1914 (*Diemyctlus viridescens*); DeKay, 1842, p. 73 (*Salamandra symmetrica*), p. 81 (*Salamandra coccinea*), p. 84 (*Triton millepunctatus*); Dunn, 1918, p. 451 (*Triturus viridescens*); Eckel and Paulmier, 1902, p. 403 (*Notophthalmus viridescens viridescens*); Eights, 1836, p. 130 (*Triturus*); Engelhardt, 1916*a*, p. 32 (waternewts); Evermann, 1918, p. 50 (*Notophthalmus viridescens*); Fowler and Dunn, 1917, p. 27 (*Diemyctylus viridescens*); Gage and Norris, 1891, p. 338 (*Diemyctylus viridescens, Diemyctylus minutus*); Gage, 1891*a*, p. 1084 (*Diemyctylus viridescens*); Green, 1923, p. 99 (*Notophthalmus viridescens viridescens*); Hamilton, 1932, p. 83, 84 (*Triturus viridescens viridescens*); Hilton, 1902, p. 643 (*Diemyctylus viridescens*); Leffingwell, 1926, p. 72 (*Triturus v. viridescens*); Mearns, 1898, p. 345 (*Diemyctylus viridescens*); Myers, 1930, p. 100 (*Triturus viridescens viridescens*); Noble, 1926, p. 1–11 (*Triturus viridescens*); Noble, 1929, p. 11; Pike, 1886, p. 17 (*Diemyctylus miniatus* and *viridescens*); Rafinesque, 1820, p. 5 (*Triturus viridescens* and *T. miniatus*); Reed and Wright, 1909, p. 404 (*Diemictylus viridescens*); Sherwood, 1895, p. 35; Smallwood, 1928, p. 96 (*Triturus viridescens viridescens*); Weber, 1928, p. 107; Wilmott, 1933, p. 162 (Waternewt); Wright and Moesel, 1919, p. 63 (*Notophthalmus viridescens viridescens*); Yarrow, 1882, p. 161 (*Diemyctylus miniatus viridescens*); 5th Ann. Rep't State Cab. Nat. Hist., 1852, p. 21 (*Notophthalmus viridescens* and *N. miniatus*); 7th Rep't State Cab. Nat. Hist., 1854, p. 26 (*Notophthalmus miniatus*); 46th Ann. Rep't N. Y. State Mus., 1893, p. 22 (*Diemyctylus viridescens* var. *miniatus*); 62d Ann. Rep't N. Y. State Mus., 1909, p. 99 (*Diemictylus viridescens miniatus*); 70th Rep't N. Y. State Mus., 1918, p. 87 (*Diemictylus viridescens*); Proc. Staten Island Inst. Arts and Sci., 1924, p. 2–4.

AMBYSTOMA JEFFERSONIANUM (Green)

(*Salamandra jeffersonianum.* Contr. Maclur. Lyc., 1827, 1(I):4, pl. 1, fig. 1)

Jefferson's Salamander: Blue Spotted Salamander

Figures *2c, 4d,* 18–22, 24, *26a-c*

Description

Size. The Jefferson salamander is a little smaller than its spotted relative, *Ambystoma maculatum,* and considerably longer and more slender than the marbled salamander, *Ambystoma opacum.* It is a very common species in certain localities, but because of secretive

habits and lack of conspicuous markings, it often escapes attention. Sometimes the discovery of the eggs will lead to a more careful search of near-by territory and subsequent discovery of the salamander itself.

In the region about Albany, N. Y., large specimens attain a length of 185 mm (7¼ inches) but the average is considerably less. In a series of fourteen breeding specimens of both sexes, the average was 162 mm (6⅜ inches). Eighteen breeding females averaged 166.5 mm in length (6½ inches) with the tail comprising 47 to 50 per cent of the total.

The relative length of body and tail is scarcely a reliable index to the sex of individuals taken out of the breeding season. Measurements show that the tail comprises 43 to 50 per cent of the total length in a large series of females and from 48.7 to 50.6 per cent in the males.

Form. The head is only moderately broad, and is widest just back of the eyes. The eyes are prominent and project beyond the lateral margins of the head when fully protruded; they are strongly retractile, however, and may be flattened to the contour of the head. The iris and pupil are black. Between the eyes and extending to the back of the head, is an elongate oval area somewhat flattened and shallowly grooved, lengthwise. The gular fold is strongly developed with a lateral extension on each side of the neck. The limbs are strong and the toes long and slender. The front feet have four toes, of which the first is shortest; others in order of length, 4-2-3; the hind feet have five toes, the first shortest and others in order of length 5-2-3-4. There are twelve costal furrows, if the axial and inguinal are counted, or fourteen when the two that come together in the groin and axilla are counted separately. The appressed legs sometimes overlap the length of the toes, but there is considerable variation.

The tail is oval in cross section at the base, but beyond is strongly compressed (particularly the distal half) and marked with conspicuous vertical grooves which are sometimes deepened near the midlateral line to form pitlike depressions. On the back, above the insertion of the hind legs, there is a flattened area with a median, longitudinal, impressed line. Slime glands are present in the skin and the openings are distributed over the entire dorsal surface and on the sides of the head, trunk and tail. They are larger and more active on the tail and pour out quantities of very sticky slime when a specimen is roughly handled. There is no definite tail construction or particular tendency toward autotomy.

The vomerine teeth are in a transverse line which is interrupted on each side back of the inner nares. In some individuals there is also a narrow break at the middle of the central line of teeth, but in others the series is unbroken. The central line may be almost straight or form an obtuse angle with the apex directed forward. The tongue is large and fleshy and almost completely fills the floor of the mouth. The lateral margins are quite free but the tip only slightly so. The plicae radiate from the posterior part of the tongue.

Color. In mature specimens the color is uniform dark brown over the dorsal surface and upper parts of the sides. The ground color of the lower sides and legs is also brown but appears lighter in some individuals because of the presence of small, irregular, pale blue fleckings. A few individuals may have these blue marks carried up to the back, but in the majority of specimens they are lacking. The venter is lighter than the back, and the blue fleckings are present, most abundant on the throat. Along the midventral line they are usually lacking.

This species is sometimes called the blue-spotted salamander, but the name is scarcely applicable to the old and large individuals. The blue spots reach their best development the year following transformation in specimens about four inches in length. In these the sides of the head, trunk and tail are conspicuously marked with irregular light blue spots which often fuse to form patches of considerable extent. The light spots are also present on the back, but here they are usually smaller and more widely separated. On the belly they are often paler in color and so numerous that much of the dark pigment of the ground color is obscured. In alcohol, specimens of all sizes may turn to uniform pale liver brown and the pale spots entirely disappear.

The successive stages in the development of the color pattern and the subsequent reduction of the light blue pigmented areas may be briefly described as follows: The recently transformed individual (figure 19b) is dull greenish gray or brownish above, somewhat lighter on the snout, legs and lower half of the sides. The belly, throat and lower side of the legs are sometimes flesh colored but often the belly is silvery gray. Some individuals are flecked with yellow on the upper sides and tail. The lower tail surface may be dull gray, lighter than the back. Usually there is scarcely any indication of the pale blue fleckings characteristic of older individuals but they may develop shortly after the gills are lost or their complete development may be delayed until the following spring. When present they

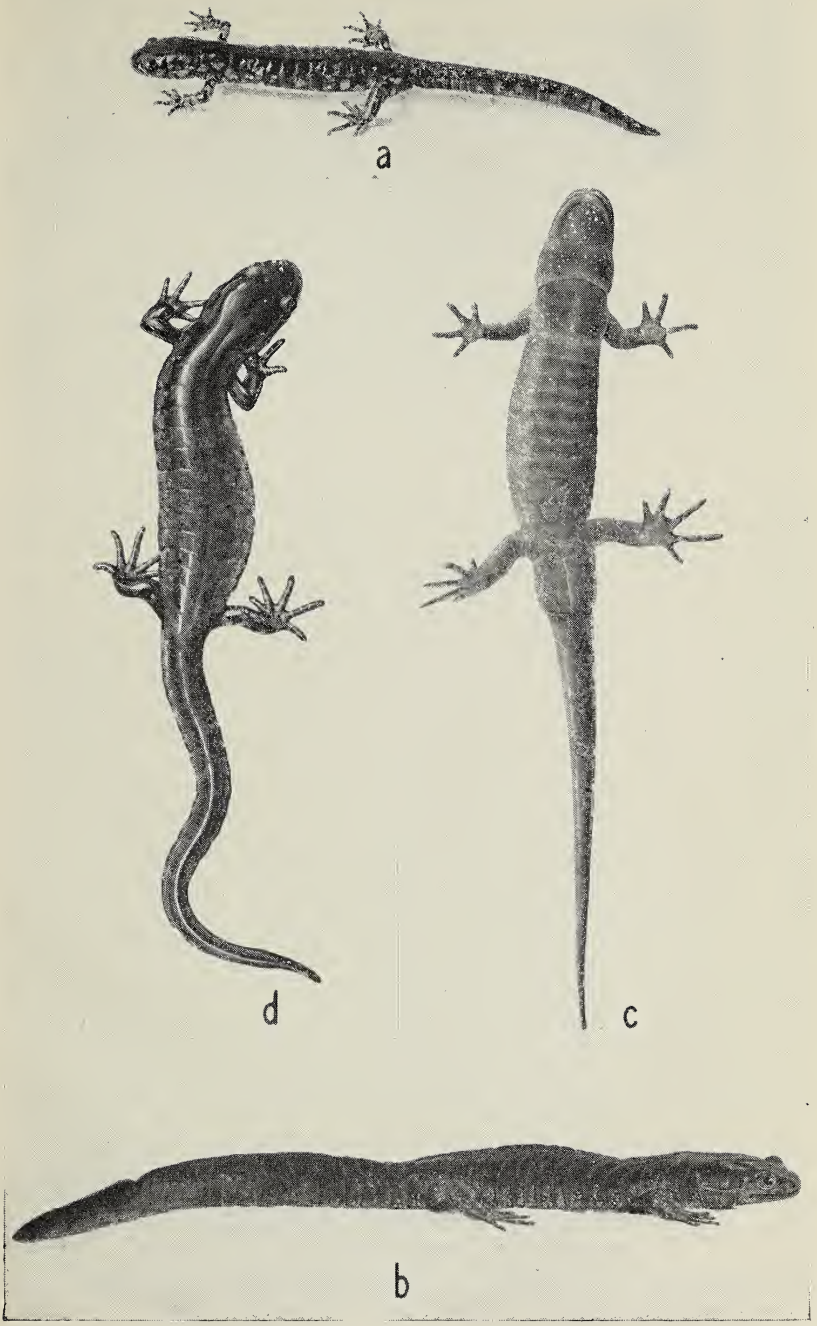


Fig. 18 *Ambystoma jeffersonianum*. a. Juvenile, New Salem, N. Y., Nov. 4, 1924. b. Adult female, Albany, N. Y., Apr. 19, 1923. S. C. B. del. c. Adult male, ventral view, Albany, N. Y., Apr. 24, 1923. E. K. O'B., del. d. Adult female, Mendon Ponds, Monroe Co., N. Y., Apr. 19, 1934. This is a smaller, darker race than that represented in other drawings.

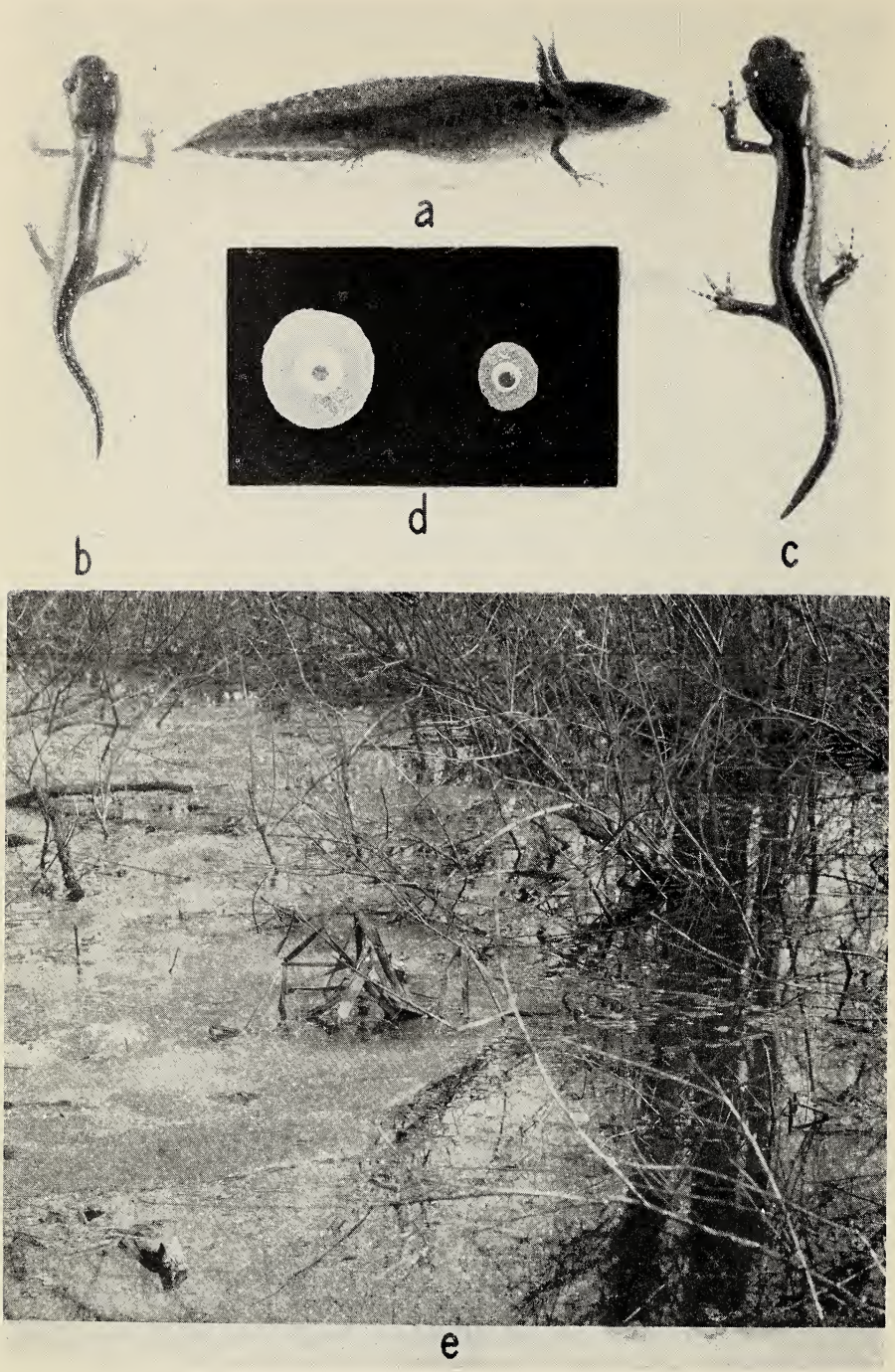


Fig. 19 a. *Ambystoma jeffersonianum*, full grown larva, July 1, 1924. Actual length 74 mm. b. Recently transformed young. Transformed Aug. 10, 1927, photographed Sept. 3, 1927. Actual length, 61 mm. c. Transformed July 21, blue spots developed July 29, photographed Sept. 3, 1927. Actual length 75 mm. d. Single eggs of *A. maculatum* (left) and *A. jeffersonianum* (right) photographed on the same plate to show the comparative size of the yolk and the relative thickness of the egg-envelops. e. Ice-covered pond at Albany, N. Y., Apr. 6, 1923, with eggs of *A. jeffersonianum* (in foreground) hanging from branches released by melting ice. Except d, E. J. Stein, photo.

are most abundant on the head and back and on the dorsal surface of the tail.

At the end of the first year following transformation when, in eastern New York individuals, an average length of approximately 107 mm has been attained, the light blue pigment areas reach their highest development. They are largely confined to the sides of the trunk and tail and to the dorsal surface of the legs, but a few smaller flecks encroach on the sides of the belly and on the ventral surface of the lower jaw.

At the time sexual maturity is reached and the adults visit the breeding ponds, the pale fleckings may be so reduced in size and number that they are scarcely evident. In some individuals, particularly those breeding for the first time, they are quite likely to be larger and more conspicuous. Fully grown individuals may have these light spots reduced to very fine speckings which are confined to the lower sides of the head and trunk and to the lower half of the basal part of the tail, and the dorsal surface of the limbs. On the ventral side there is a rather general distribution of the flecks on the throat and under surface of the limbs but on the belly they are limited to the sides. A few inconspicuous spots may also be present on the sides of the vent and basal part of the tail.

Sexual differences. There are no striking differences in the sexes except in the breeding season, when the most conspicuous feature in the male is the greatly swollen and protuberant vent. The female may have the vent slightly enlarged but never to the extent found in the male. Other differences which are apparent with specimens in the hand are as follows: (1) the tail of the male is a little longer and slightly more compressed though no deeper, (2) the distance between the legs is shorter, (3) the head tends to be broader and flatter than in the female, (4) both hind and fore legs and toes of the male are longer and larger so that the appressed limbs may overlap the length of the toes, while in the female as much as two costal interspaces may separate the toe tips. The overlapping of the toes in the appressed limbs of the male is not altogether due to the greater length of the limbs for the body length of the female between the limbs is greater.

Activities of the Breeding Season

Migration. In the latitude of Albany, N. Y., a few consecutive warm days in March or early April, accompanied by rains or a rapid run-off of snow water, are usually sufficient to arouse the Jeffer-

son salamanders from their winter retreats and start the annual migration of adults to the breeding ponds. In parts of its range where it may share the breeding waters with *A. maculatum,* the Jefferson salamander may be expected to deposit its eggs some four or five days before the first of the spotted salamanders arrive. In some years a few individuals may precede *A. maculatum* by as much as ten days.

The migrations are performed by night under normal conditions but may continue during daylight hours if the animals fail to reach the ponds and are unable to find shelter.

If the conditions that serve to initiate the migration of adults continue for a considerable period, the bulk of the salamander population in a particular locality may reach the breeding ponds in one grand rush. In most years, however, a few warm days are followed by sharp, cold periods which effectively halt the migratory movements and send the Jefferson salamanders into hiding until the weather moderates again. Under such conditions several successive migration waves follow one another, each coincident with the return of periods of rising temperatures and usually with warm rains. When suitable weather continues for several successive days, some of the Jefferson salamanders are likely to hide, by day at least, under cover near the margins of the ponds. On a falling temperature and in the absence of suitable cover, they usually enter the water at once and may remain throughout the breeding period.

Any advantage in the way of food or shelter that may be derived from the early occupancy of the breeding ponds, seems to be offset in the long run by the dangers incident to travel at this season of the year. A sudden lowering of the temperature may cover the surface of the ponds with ice and freeze the migrating individuals before they reach shelter. On the morning of April 5, 1923, eight females were found dead at the margin of a shallow ice-covered pond at Albany, N. Y. They had failed to reach open water. In attempting to cross wide, open, meadows they are sometimes overtaken by the sun and die, leaving their dried bodies to mark the spot. Some years it is difficult to understand how the Jefferson salamanders reach the ponds so early in the season, when ice covers the surface almost completely and the surrounding ground is still frozen and, for the most part, snowbound. On April 2, 1926, these salamanders were to be found in the ponds under the ice but in the nearby woods, logs and bark and fallen trees were still frozen solidly to the ground. Only on the south slopes had the frost line

retreated below the surface and here scarcely enough to release the salamanders from hibernation.

Certain ponds, probably ancestral breeding places, are visited year after year by this salamander, and year after year the ponds dry up before most of the larvae have time to transform. Other ponds in the vicinity, which may differ only in that they are permanent, are never visited, although they lie near the line of migration. The instinct which leads a salamander to certain waters for breeding may well be the most important factor in the extermination of the species in that locality. The character of the land surrounding the pond may change due to the clearing away of the forests and tilling of the soil, the distance from suitable winter hiding places to the pond may be greatly extended, but the Jefferson salamanders will often attempt the journey. Having once attained the water they are comparatively safe, for their color blends perfectly with the rotting leaves and muck of the bottom and a few strokes of the broad tail drive them beneath the loose rubbish. There is food, too, in abundance, for in early spring the earth worms crawl over the bottom. In open water in certain ponds there are myriads of *Eubranchipus,* half grown and of a brilliant orange-red color. It is doubtful, however, if much food is taken during the breeding season.

The majority of individuals visiting any particular pond probably travel comparatively short distances, for this species frequently winters in close proximity to the breeding ponds. Occasionally an individual may be found at least a mile from the nearest open water and it may be assumed that at breeding time an attempt will be made to return to the pond.

Mating. On the night of April 13, 1926, the mating activities of the Jefferson salamanders were observed near the margin of a shallow hilltop pond at Albany, N. Y. Many individuals were crawling slowly about the pond and occasionally rising to the surface to take in a mouthful of air. A group of four attracted attention, when observed with the aid of a flashlight, for they were milling together among the rotting leaves of the bottom. Soon a pair embraced, the male clasping the female, his forelegs just behind hers (axillary embrace) and maintaining his hold until the female crawled away beneath the bottom rubbish. The two other specimens crawled and swam about the clasping pair, rubbing against them and at times nosing them vigorously. Their large size and distended abdomens showed them to be females and they were apparently bidding for the attention of the male. At the

same pond on April 14th another group of four was seen, but on this occasion one was a specimen of *A. maculatum.* A male and two female Jefferson salamanders composed the rest of the group and all were engaged in swimming and crawling about one another. Further observations at the same pond were made on the night of March 25, 1928, when 22 females and two males were engaged in mating activities, each of the males attended by three or four females. The Jefferson salamander has also been observed to embrace in aquariums. According to Wright, 1908, p. 286:

Mr. Arthur A. Allen secured in Buffalo, N. Y., March 29, 1907, five individuals of *Amblystoma jeffersonianum.* Upon returning from his collecting trip he put them into a receptacle and immediately the smallest one (♂) embraced another (♀) exactly after the manner of the spotted newt. (This would imply that the hind legs were used in clasping.) At Ithaca, April 12, after he had transferred them to a larger aquarium jar the same individual repeated the performance. The embrace continued for some time. Neither eggs nor spermatophores were subsequently laid.

In the breeding ponds near Albany where I have studied the species, the females apparently greatly outnumber the males, in all breeding specimens collected, the ratio being about eight to one. This ratio may or may not represent the actual difference in number for the females, particularly when carrying eggs, are less active than the males and more easily collected. Furthermore, until the sex of the progeny of a considerable number of individuals is determined, we have no definite way of establishing the ratio.

These observations on the sex ratio of specimens collected at Albany, N. Y., are not in agreement with those made by Mohr (1930, p. 50) in Pennsylvania, where of 62 specimens collected, 40 were males and 22 females. The disproportionate number of females in the ponds at Albany may very likely account for their actions in bidding for the attention of the males.

In the region about Rochester, N. Y., I have not had sufficient material to determine accurately the sex ratio but the females in my collection greatly outnumber the males.

Doubtless it will be recognized that there are more or less distinct races of the Jefferson salamander whatever their status may be in taxonomy. The form from the vicinity of Rochester, and perhaps throughout western New York, differs from that found at Albany. The Rochester specimens I have seen average smaller, are generally darker, and breed at a much smaller average size.

Clanton (1934) has called attention to an interesting situation in the Jefferson salamander population of southern Michigan. Here two forms of adults have been recognized, both apparently distinct from the eastern New York variety. "One, designated as dark, is found in nearly equal numbers of each sex; the other, designated as light, is composed almost entirely of females." (p. 13.) He also recognizes these two forms among western New York material. Clanton suggests that the light females are hybrids resulting from the interbreeding of two forms or races and that the abnormal sex ratio in specimens collected in western New York also indicates a hybrid condition.

Kumpf and Yeaton (1932, p. 1–7) have presented some observations on the courtship behavior of *Ambystoma jeffersonianum,* based on the activities of specimens in captivity. Some of the males, at least, were stimulated by pituitary transplants. Such observations, while of value, should not be presented as representing the normal sequence of events without confirming evidence derived from observations in the field under natural conditions.

The mating activities of specimens in confinement may be briefly summarized as follows: the male usually mounts upon the back of the female in a position to bring his fore legs behind (more rarely in front of) the fore legs of the female. While thus mounted the male stimulates the female to sexual activity by undulations of the body and by rubbing his chin over her head and snout. Following these efforts of the male, he moves forward and ahead of the female and often drops a spermatophore. The female follows if sufficiently stimulated, and recovers the sperm cap, or the entire spermatophore, with the cloacal lips. If the female evidences little interest in the proceedings, the male may fail to deposit the spermatophore.

As noted in an earlier paragraph, mating activities in the field under natural conditions involve factors that may not be present in the laboratory tank, for example, the presence of individuals of other species that interfere, the milling and rubbing of a number of individuals of both sexes preliminary to clasping and finally, under some circumstances, the effective superiority of the females, whether or not they are actually numerically superior.

Spermatophores. The spermatophores of *A. jeffersonianum* are deposited singly (Mohr, 1931, p. 103) in comparatively shallow water and are attached to twigs, leaves, grass, stones and other bottom rubbish. They are widely scattered in contrast to the dis-

position made by *A. maculatum* where usually the spermatophores are deposited in groups of a dozen to a hundred or more.

The individual spermatophore (figure 21 *b*) is a small pyramidal structure with the basal part composed of fairly transparent jelly and the apical part surmounted by a comparatively small, whitish sperm mass. It may be distinguished from that of *A. maculatum* by its smaller size and more slender build, by the narrowness of the apical part and by its color. In *A. maculatum* the sperm are not only aggregated at the summit of the spermatophore, but the whitish seminal fluid often covers a considerable portion of the gelatinous basal support. In *A. jeffersonianum* the sperm-sac is confined to the apex of the supporting basal part.

Mohr (1932, p. 102) reported the discovery of spermatophores in ponds near Woodward, Center county, Pa., March 25–27, 1931, and at the same time recovered a number deposited by individuals in aquaria. Mohr (*ibid.* p. 104) also noted the actual deposition of spermatophores both in the field and laboratory. He states:

A male was seen to be vigorously undulating his tail and the whole posterior part of the body. Several times he clutched convulsively at the ground with his hind legs. A female approached, nosing the cloacal region of the male, which almost immediately deposited a spermatophore. The male crawled very slowly away, undulating his tail feebly. The female followed and came to rest with the cloaca immediately above the spermatophore and remained motionless for perhaps fifteen seconds, then pushed slowly after the male into deeper water. The spermatophore appeared intact; probably relatively few of the spermatozoa enter(ed) the cloaca.

The egg-laying process. The eggs are usually deposited at night but the process may be continued by day, if it is dark or rainy. The gravid females swim and crawl about the pond, seeking a suitable support which may be a submerged branch, the stem of an aquatic plant or the tip of a limb dipping into the water. The position assumed by the female while she is depositing her eggs can scarcely be regarded as a graceful one. The support chosen usually lies only a few inches below the surface, and on this she sprawls with fore legs out-thrust or held back against the sides, and the hind legs directed backwards to bring the thighs in position, one on either side of the vent. No attempt is made to cling to the support, if it is horizontal or nearly so, and so precarious is her position that the slightest disturbance may cause her to lose her balance. She is careless in the matter of placing her eggs, and several may miss the support entirely and fall to the bottom of the pond where they are to be found as perfect spheres, each with a

full complement of envelops. As the eggs are extruded, the back is strongly arched and the tail is curved aloft and sometimes slowly waved from side to side while the hind legs are directed backward (fig. 21a). The eggs appear one at a time and, as they come in contact with the support, the viscid outer layer clings tenaciously. After a few have been deposited, the female may hitch herself forward to prevent an accumulation at one point. They may appear at the rate of four a minute; usually, however, several minutes are consumed in depositing an average-sized batch containing about 16. On one occasion seven eggs were laid in a three-minute period. The interval between batches also varies considerably, from one-half of an hour or less to several hours and the deposition of the entire complement may be extended over a period of 24 hours. The size of the individual egg mass seems to be governed by circumstances. If the female is not disturbed during ovulation, all the eggs that occupy the cloaca at any one time may be deposited in one mass. If disturbed, she moves away and begins over again. The entire complement may be attached to a single support with the masses in contact.

The female expresses no concern for the eggs after depositing them and, shortly after the process has been completed, the ponds are deserted. The adults travel again to the shelter of the neighboring woods where, for a time, they may be found more or less concentrated under logs and bark on the ground. Later in the season they are more widely dispersed and difficult to find.

Air temperature and rains are the important factors in initiating the migrations of the adults to the ponds, while water temperature plays the important role in the development of the eggs. On the other hand, water temperature apparently has very little to do with the deposition of the eggs. The presence of the males in the breeding ponds, the stimulation attending the courtship proceedings, (clasping, nosing etc.) deposition of spermatophores and their subsequent recovery by the females, are a series of events which may culminate in the egg-laying regardless of the temperature.

A period of cold weather during March 1928 which had blanketed the ponds at Albany, N. Y., with two or three inches of ice was followed on March 25th by a rise in temperature accompanied by rain which covered the ice to a depth of perhaps two inches. On the night of March 25th, salamanders were present in considerable numbers on the ice and several females were observed in the act of depositing their eggs. In this instance, certainly, the water temperature was scarcely above the freezing point.

It has been a matter of frequent observation that many of the eggs deposited early in the season fail to hatch. Piersol (1929, p. 60) believed that in some instances intense polyspermy followed the deposition of eggs in water of low temperature while other eggs of this species under the same conditions remained unfertilized. In view of the fact that many more females than males have been found in the ponds at Albany and that spermatophores of this species are comparatively few in number, it is altogether likely that some females are left without mates. This may well account for unfertilized eggs but not for the polyspermy.

The egg mass. The eggs are deposited in small masses which contain on the average about 16, but the number varies from 7 to 60 and often single eggs are dropped, or small clusters of three or four. The mass usually surrounds some slender supporting twig or grass stem or is rarely fastened to the margins of leaves. When first deposited the jelly is clear and transparent and the jelly surrounding freshly laid eggs is small in bulk and confines the eggs in a compact group at one side of the support. With the absorption of water and consequent swelling, the eggs are carried around the support and sometimes exhibit a spiral arrangement. A typical egg mass is about two inches long, one inch in diameter and roughly cylindrical in shape. The jelly envelop surrounding the eggs is comparatively thin and, because of this, the eggs close to the surface break the smooth contour of the mass. Often three or four and sometimes seven to nine clusters are attached to the same support and form a continuous mass which may be twelve inches long.

The masses are ordinarily attached within six inches of the surface of the water and subsequent lowering of the level may expose them to the air. The eggs survive this exposure for a short time, partly protected by the drying of the outer surface of the jelly; but continued exposure results in their destruction. Before the eggs hatch the jelly mass may swell to double the normal size, becoming very soft and covered with silt and algae. A single large female in captivity deposited 166 eggs in the course of 24 hours. These were distributed in five large masses and several smaller ones. A specimen 185 mm long, taken April 10, 1926, and placed in an aquarium, laid 173 eggs on the following day. A smaller individual only 150 mm long, taken April 13, 1926, deposited 215 eggs during the night and day following. Another female 161 mm long, taken at the same time, deposited a total of 286 eggs within a period of

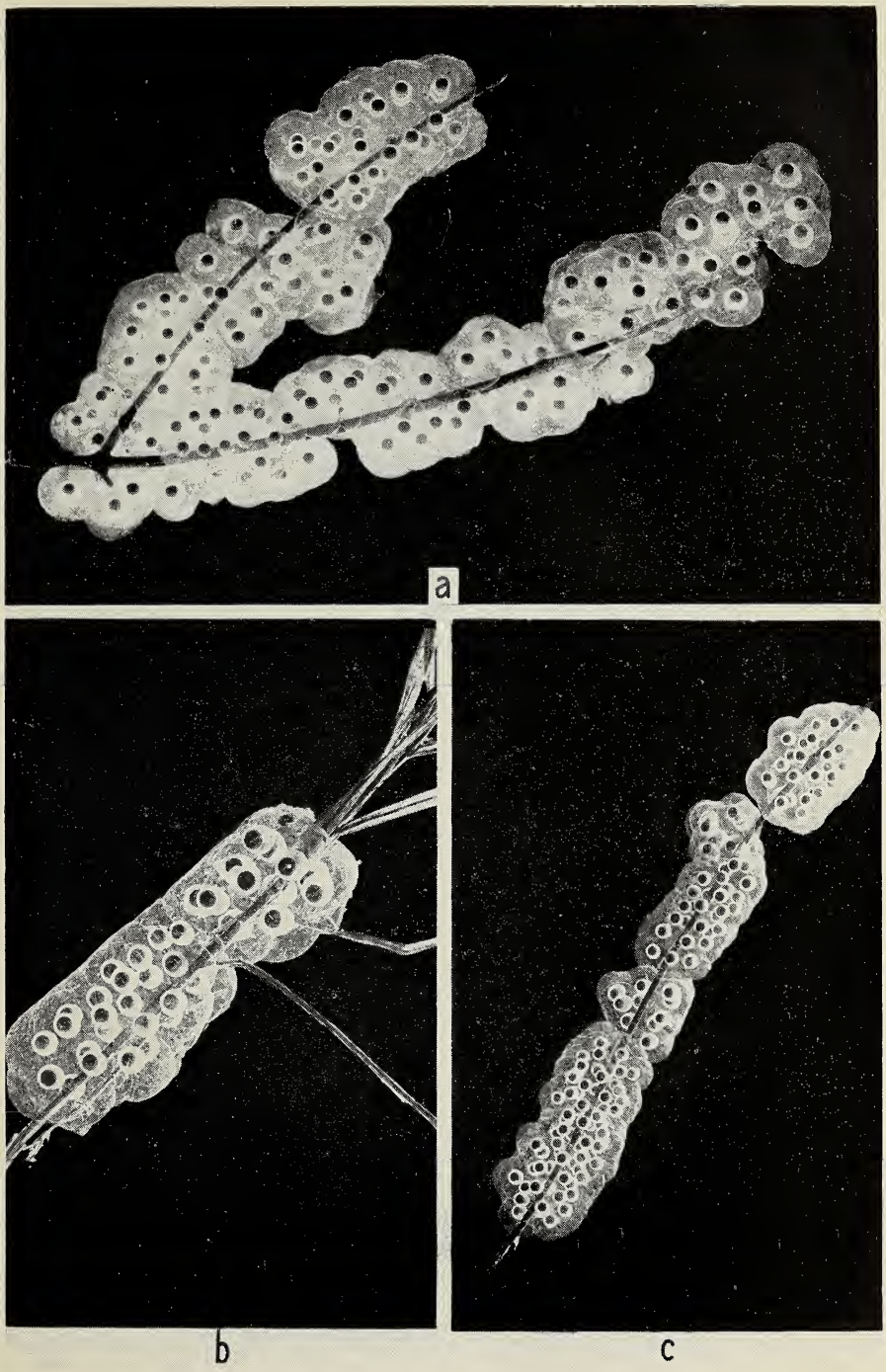


Fig. 20 a. Egg masses of Jefferson's salamander, *Ambystoma jeffersonianum*. The clusters strung along a slender twig sometimes form a continuous mass nearly a foot in length. Albany, N. Y., Mar. 29, 1927. b. Two typical clusters, about natural size, to show milky inner envelops. c. Five egg clusters on a single slender twig. The variation in size and shape is here indicated. S. C. B. and E. J. S., photo.

24 hours. Four medium-sized specimens dissected in November had respectively 107, 123, 180 and 216 eggs of uniform size and many smaller ones.

Development

The egg and its envelops. Individual eggs have a diameter of 2 to 2.5 mm when first deposited. They are surrounded by envelops disposed as follows: first, the thin and transparent vitelline membrane which is closely appressed to the egg. It is ordinarily invisible but is apparent under the microscope when development has advanced sufficiently to break the regular contour of the egg surface. The second true envelop is comparatively thick and incloses a thin, watery jelly in which the egg apparently floats. This envelop is ordinarily clear, but in some cases is slightly milky. The third definite membrane is rather tough and is in contact with the second. Outside of this is a fourth layer of the same thickness. Besides these individual envelops, the eggs are aggregated, as before mentioned, by a jelly covering which has the appearance of a common envelop but which in reality is simply the fused outer, or fifth envelop, as described by Storer (1925, p. 35) for certain California salamanders. If the outer layer is disregarded the egg and its envelop will measure about 4 mm in diameter; the next layer within about 2½ mm. Compared with the eggs of *A. maculatum,* those of *A. jeffersonianum* are slightly smaller (figure 19*d*).

When laid, the color of the upper pole of the egg varies from dark brown to black and the dark area covers from one-half to two-thirds of the surface. Below they are somewhat lighter. Ovarian eggs are almost entirely black above and only slightly lighter below.

The eggs of the smaller, darker race in western New York are deposited in small compact masses, usually with but a single lot attached to one support.

The incubation period. The eggs may hatch in from 13 to 15 days in the laboratory, kept at ordinary room temperature, 68°–72°F. In the open waters this period is considerably extended. Eggs in early stages of development, taken April 8th, hatched at room temperature April 22d; in the field, the eggs continued to hatch until May 4th. Before the eggs last deposited are hatched, the adults may leave the ponds and migrate again to the woods. In 1923 the adults had left the ponds by April 24th and were to be found in the wooded ravines, hiding by day under loose pieces of bark and logs. In 1924, eggs deposited April 4th, hatched in the laboratory April 18th, two days before the last fresh eggs were

deposited in the ponds. The eggs hatched in the pond April 9th, so that the period of incubation covered an interval of 35 days. In 1923 this interval was only 30 days. In 1925, eggs deposited March 18th, were hatching April 25th, an incubation period of 39 days. Eggs laid April 5, 1926, were hatching May 7th, an incubation period of 32 days. In 1927 a week of warm weather with frequent rains in the middle of March started the egg laying on March 16th, but colder weather following delayed hatching until April 30th and established an incubation period of 45 days.

Below, in tabular form, are given the dates of deposition of the eggs, the date of hatching and the length of the period of incubation during the five-year period 1923 to 1927, at Albany, N. Y.

DEPOSITED	HATCHED	PERIOD OF INCUBATION	TRANSFORMED
April 4, 1923.....	May 4, 1923..	30 days.....	
April 4, 1924.....	May 9, 1924..	35 days.....	July 4 to Sept. 13
March 18, 1925.....	April 25, 1925.	39 days.....	Aug. 1
April 5, 1926.....	May 7, 1926..	32 days.....	
March 16, 1927.....	April 30, 1927.	45 days.....	July 22–Aug. 10

The newly hatched larva. Larvae at hatching have an average length of 13 mm but vary from 10 to 14 mm. They are strongly pigmented above, the color varying from olive-green to brown, with tinges of yellow on the sides of the head and neck and sometimes along each side of the dorsal fin. Small spots of black pigment are distributed freely over the surface and are concentrated at the sides of the head and upper sides of the trunk and tail in areas forming paired spots, a series on each side of the middorsal line. The fin is dusky white with small areas of yellow and light brown pigment and a few small scattered black spots. The lower sides and belly are lighter than the back, colored by the yolk. The above description applies particularly to larvae hatched under normal conditions in the ponds. When the eggs and developing embryos are exposed to strong light and placed over a light background, a color pattern is developed which differs markedly from the normal in the strong contrast between ground color and pigmented spots. In these individuals the ground color is a light greenish gray or greenish yellow. Clusters of small, black, rounded pigment spots are scattered irregularly over the head, but on the trunk and tail they are concentrated in some five or six vertical bars which are about half as wide as the lighter interspaces.

Viewed from above, the body back of the head is extremely narrow and tapering and the upper extremities of the lateral dark bars appear on each side of the middorsal line as pairs of dark spots. The gills, tail, fins and tips of the balancers are also lightly pigmented. This type of pattern is present on larvae hatched in ponds, but the ground color is darker and the contrast less striking.

The head of the newly hatched larva is broad, almost twice as wide as the body and has the sides parallel. The snout is blunt. The balancers are club-shaped and are attached a little below the level of and midway between the eyes and the first pair of gills. The gills are well developed with two rows of filaments. The middle gills are longest, about the length of the head.

Before hatching, the balancers are evident as backward projecting buds in line with the gill buds. The pupil of the eye is black, the iris yellowish with small, darker flecks. The fore legs are represented by elongate buds directed backward. The hind legs are not in evidence at hatching. The tail fin is broad, wider above the tail vertebrae than below, and is continued over the back to a point almost above the insertion of the fore legs. The balancers are used to support the body when resting on a smooth surface and sometimes function when the larvae hang from bits of algae or other water plants. They are retained for a period of from 10 to 16 days and are not absorbed, but gradually constrict at the base and drop off, leaving a short, rounded knob which soon disappears.

Length of the larval period. The larvae of the Jefferson salamander normally hatch the latter part of April or during the first two weeks of May in the latitude of Albany, N. Y. The earliest date on which transformed individuals were found was July 4, 1924, and in that year the young hatched on May 9th. This gives a larval period of only 56 days for certain individuals. Other apparently mature larvae taken at the same time and transferred to the laboratory for observation, did not lose their gills and come out of the water until September 13th, an additional period of 69 days or a total larval period of 125 days. Thus the length of the period is extremely variable. With the drying up of the ponds, transformation is sometimes speeded up and mature larvae are enabled to adapt themselves rapidly to the changed conditions. The smaller larvae, however, die every year by the thousand in temporary ponds.

Throughout the larval period and until nearly full grown, the larva of *A. jeffersonianum* is usually more heavily pigmented than that of *A. maculatum* and more strongly mottled and blotched.

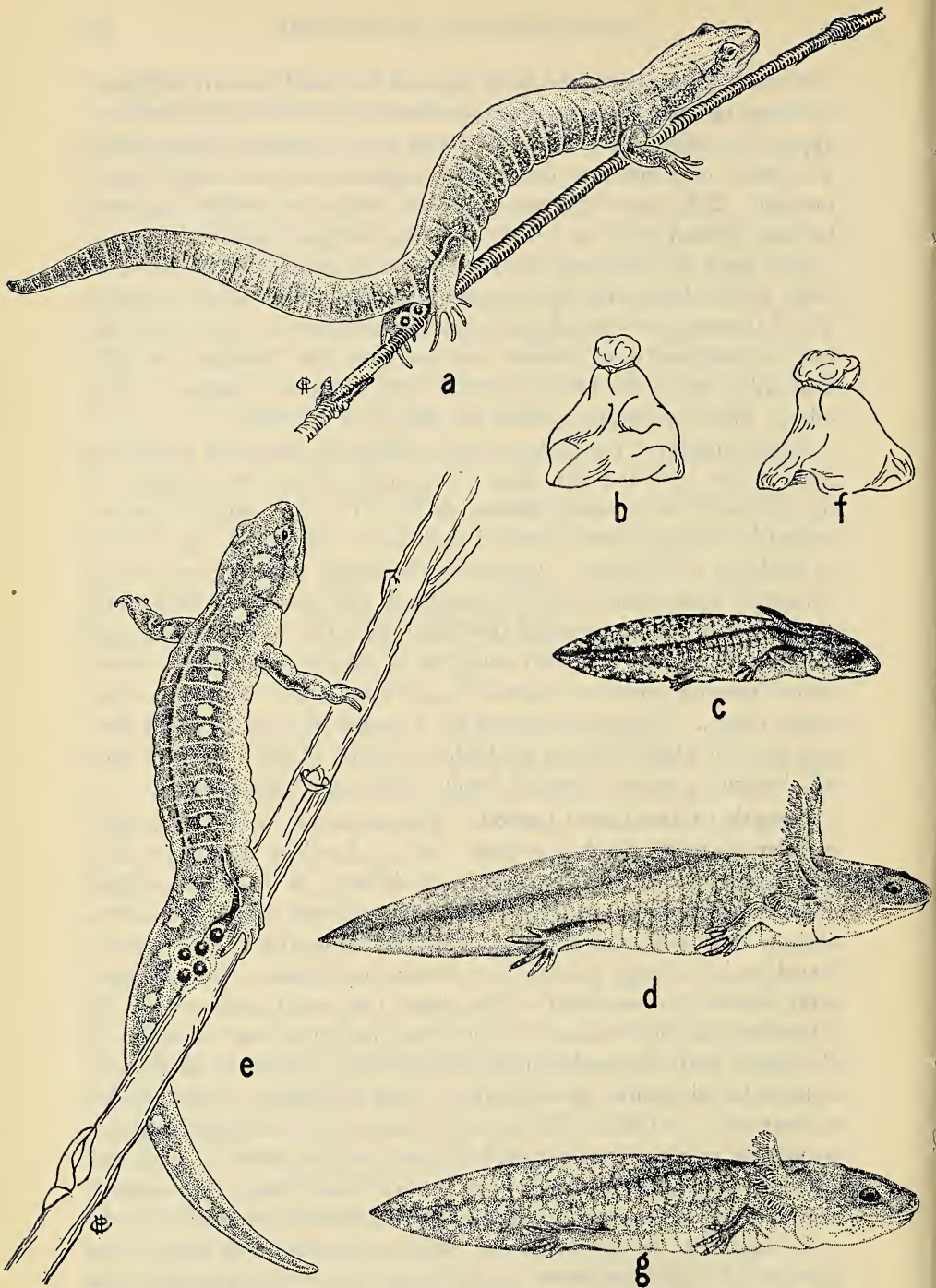


Fig. 21 a. *Ambystoma jeffersonianum*, female depositing eggs. b. Same, spermatophore (after photo by C. E. Mohr). c. Same, larva, Albany, N. Y., June 12, 1924. Actual size 33 mm. d. Same, full grown larva, Albany, N. Y., July 3, 1926. Actual length 62 mm. e. *Ambystoma maculatum*, female depositing eggs. f. Same spermatophore. g. Same; larva, Albany, N. Y., July 3, 1926. Actual length 55 mm. a. and e. drawn by H. P. C.; c., d. and g. by H. E. R.

When fully developed, however, they are less strongly mottled than *A. maculatum.*

I have tested my ability to discriminate between the larvae of the two species by separating them, by the color characters indicated above, and carrying them through transformation.

Mature larvae. Mature larvae vary in length from 48 to 75 mm. They are broad-headed, strong-bodied creatures with well-developed legs and gills. The snout is very broadly rounded and somewhat flattened. The sides of the head are almost parallel and bluntly angled at the point of attachment of the gills. The neck is slender, only half as wide as the head. The gills are strongly developed, but relatively shorter than in newly hatched larvae.

The color above is almost uniform dull greenish gray in the majority of specimens but tends toward yellowish brown or gray in others. There is a darker central area on the head, marking the position of the brain, and a small dark spot in front of each eye, extending obliquely from the eye to the nostril. Viewed from the side, the color is remarkably uniform in most specimens, dull greenish or yellowish gray on the upper half but tending to become bluish and iridescent on the lower half. The tail fins are slightly mottled with small yellowish spots on a gray ground color. The dorsal tail keel is practically straight from its origin above the fore legs to the tip of the tail. The belly is free from pigment except along the sides where there may be a single indistinct line of small light yellow spots on each costal fold between the fore and hind legs. The belly is silvery, iridescent or with a pinkish cast. The throat is bluish white or white, the lower lip margined with dusky. The pupil of the eye is black and the iris next to the pupil bright golden yellow. The outer rim of the iris is deep blue. Compared with the larva of *Ambystoma maculatum,* the Jefferson larva is generally lighter, more uniform in color and with less mottling on the tail. The eye has the iris of a brighter golden yellow, the toes are proportionately and actually a little longer and more definitely flattened. Described from a mature larva taken July 3, 1926.

Transformation. In 1924, when the first eggs were deposited on the night of April 4th, transforming larvae were found in the field on July 4th. Thereafter, they continued to transform until September 13th. Drying of the ponds will hasten transformation if the larvae are well advanced. They may transform when only 48 mm long, or continue to grow without gill reduction until they reach a length of 75 mm.

The newly transformed individual is dull greenish gray or brownish above, lighter on the snout, legs and lower half of the sides. The absorbed dorsal fin leaves a dark median line extending from the back of the head to the tip of the tail. The belly, throat and lower side of the legs and feet are sometimes flesh colored; but more often the belly is silvery gray. Some individuals are flecked with yellow pigment on the upper part of the sides and tail. The lower tail surface is dull gray, lighter than the back. The sides between the legs are often distinctly bluish.

The pale blue spots, which are characteristic of older individuals, sometimes develop shortly after the gills are lost, often within a week, but sometimes delay their complete appearance until the following spring. When present they are usually more conspicuous on the head and back (where they are almost always lacking in the full grown adult) than on the sides where, in the adult, they are present, if anywhere.

The most conspicuous changes accompanying gill reduction are: first, the loss of fins on tail and back; second, the blunting of the toe tips; third, the redistribution of pigment; fourth, the rounding up of the head and snout and, fifth, the change of habitat. From a very active, day-feeding, aquatic larva there is a change, almost overnight, to the land form which is comparatively sluggish and entirely nocturnal.

Development to maturity. Measurements of 35 specimens collected at New Salem, N. Y., on November 4, 1922, will give some idea of the rapidity of growth of the species. Seventeen of the specimens which had very evidently transformed that season varied in length from 52 to 78 mm and averaged 62 mm. The 16 remaining specimens averaged 107 mm in length and represented the growth, following transformation, of approximately 15 months. The largest individuals of this group were females 135 mm long with well-formed eggs in the ovaries. A female only 112 mm long had eggs 1.7 mm in diameter. The comparatively large size of the eggs indicates that the females may be sexually mature and ready to deposit eggs in about 21 months after transformation. Gravid females in the ponds at Rochester may be only 114 mm long, but all the specimens I have collected during the breeding season at Albany are much larger, averaging about 165 mm in total length.

Habits

General. The animals are essentially nocturnal in their habits and given to burrowing in the loose soil and leaf mold. It is only

during the egg-laying season that they may sometimes be found during the daylight hours, and even while in the water most of the time is spent in hiding. On dark days, however, they venture out and even deposit their eggs.

When the young crawl out of the breeding ponds at transformation, they make their way to the woods and hide among the debris of the forest floor. In October, or November, if the weather is mild, the young of the year and those individuals approaching maturity, which transformed the year before, sometimes congregate in numbers beneath logs and bark. Twenty to thirty or more often select the same shelter and remain until cold weather forces them into winter quarters beneath the deep leaf mold or under old rotting logs and stumps.

If the soil is loose and porous they may burrow to a considerable depth, a foot or more, but where the soil is heavy they sometimes merely burrow beneath a log or stone and take up quarters on the soil beneath. Under such conditions it will be found that the salamanders have selected a spot beneath a concavity of the stone or crevice in the log so that they are provided with a small air space and are in contact only with the ground. In such a situation they are often not below the frost line.

On January 23, 1933, Hugh and Betty Chrisp and W. L. L. Peltz of Albany unearthed five individuals from beneath old cross ties on the abandoned bed of a railroad. Three were found singly but the other two were clasped together so that when the uppermost was picked up the second specimen was lifted a foot or more before it was released. In the group of five were two males one of which exhibited the cloacal glands in a somewhat swollen condition. Among the females were two with distended abdomens indicating that the eggs had reached an advanced stage of development. Unfortunately, the sex of the clasping individuals was not determined at the time of capture.

It is, of course, dangerous to draw conclusions from the scant evidence of a single observation but if a male and female were clasped together it is suggestive of the sporadic fall and winter mating activities of the newt and may have its origin in the stimulus arising from the actively developing gonads.

In the early spring the young are again to be found in numbers, much as in the fall but the adults seem not so gregarious. In late summer or fall a pair of adults sometimes occupy the same retreat but they are not easy to discover in numbers.

Food. The food of adults consists of earthworms, insects and their larvae, millipedes and spiders. Larvae take various small aquatic organisms including Entomostraca, insects and worms. They are also cannibalistic, taking smaller individuals of their own species and often preying on the larvae of *A. maculatum,* which are usually smaller than those of *A. jeffersonianum* at the same time of the year.

Habitat. I have found this salamander in great numbers in deciduous woods bordering swamps and slow streams, in mixed woods of beech, chestnut, oak, maple and hemlock surrounding temporary pools, and on river flats where there were a few scattered maples and elms of great size and an undergrowth of alders and willows. A few individuals have been turned up in moist soil at least a mile from the nearest breeding waters. Where the species is most successful, measured by the abundance of individuals, the essential features of the habitat are quiet waters for the egg-laying period and mixed or deciduous woods near at hand for the rest of the year.

In the low, wooded and partly swampy ground bordering the Clyde river in Wayne county, this species was formerly so abundant in the fall that several hundred individuals might be discovered in the course of a few hours by turning old logs and bark on the ground and raking the damp leaf mold. Young of the year and those a year older predominated but adults of all sizes were also present though more widely scattered and usually taken singly.

The ponds near Albany to which the Jefferson salamander resorts for the egg-laying season are often shared with the spotted salamander, *Ambystoma maculatum,* the newt, *Triturus v. viridescens,* the wood frog, *Rana sylvatica,* spring peeper, *Hyla crucifer* and some of the larger species of rana, the pickerel, leopard and green frogs. At the time of egg-laying of the Jefferson salamander, however, only the four species first mentioned are likely to be at hand to compete for food and space.

Remarks

Following the description of the species by Green in 1827, a number of early zoologists including Baird (1850), Cope (1867), DeKay (1842), and Holbrook (1842) gave brief accounts of this salamander but contributed very little to the knowledge of its habits.

DeKay (1842, p. 78) gave a description and figure of the species (pl. 23, fig. 66) described by Holbrook as *Salamandra granulata;*

but the specimens, said to have been collected in northern New York, were sent to the National Museum and were identified as *jeffersonianum*. There is very little in the description and figure to indicate its identity with *A. jeffersonianum* and in the absence of the specimens one would be likely to place it elsewhere. The figure shows a very short-toed, round-tailed salamander much more suggestive of *Plethodon glutinosus* than *A. jeffersonianum*. DeKay's *Triton niger* (p. 85, pl. 15, fig. 35) on the other hand, has the general appearance of *A. jeffersonianum*. The toes, as shown in the figure, are long and slender with light joints and the tail is somewhat keeled. DeKay characterized this species briefly, mentioning the black back, sides with small white spots and compressed tail as long as the body. This may represent *Desmognathus fuscus fuscus*, however.

Peirsol seems to have been the first to describe and figure the eggs of this species (1910, p. 732). Smith (1911, p. 14) compared the egg mass of *A. jeffersonianum* with those of *A. tigrinum* and *A. maculatum* and presented useful figures. Wright (1908, p. 286) mentioned the observations of Arthur A. Allen who first witnessed the embrace in this species and I have subsequently observed the same phenomenon. The spermatophores are described by Mohr

Fig. 22 New York localities for *Ambystoma jeffersonianum*.

(1931, p. 102), figured and compared with those of *A. maculatum*. Mohr also gave additional details of the early breeding habits based on observations on a considerable number of embracing pairs.

Courtship behavior of individuals in captivity is reported by Kumpf and Yeaton (1932).

Range

From Hudson Bay in Canada through New England, New York and Illinois southward to Virginia, westward to Wisconsin, Illinois and Arkansas.

Distribution in New York

General. Quite widely distributed but records are lacking from most of the Southern Tier counties. It is likely to be found, where suitable conditions prevail, all over the State.

Specific records. ALBANY: *Albany,* Apr. 24, 1923, 1 ad. N. Y. S. M. No. 9483; Apr. 4, 1924, 1 ad.; Apr. 5, 1924, 2 ads. (S. C. B. and W. J. S.); Apr. 14, 1924, 1 ad.; Mar. 28, 1925, 1 ad.; Aug. 1, 1925, larvae and transforming yg.; Apr. 10, 1926, 1♂, 3♀; Apr. 13, 1926, 1♂, 8♀, eggs. N. Y. S. M. No. 3036, 3038 (S. C. B., W. J. S. and H. H. Cleaves); Apr. 14, 1926, 5♀ (S. C. B. and B. S. B.); Apr. 15, 1926, 1♂ (S. C. B. and H. H. Cleaves); Mar. 17, 1927, 1♀, eggs (S. C. B. and E. J. Stein); Mar. 18, 1927, 1♂, 8♀ (S. C. B. and W. J. S.); Apr. 14, 1927, 2♂ (S. C. B. and J. L. Cooley); July 13, 1927, many mature larvae; 1 ad. N. Y. S. M. No. 3955; July 18, 1927, 1 ad. N. Y. S. M. No. 3954; larvae, N. Y. S. M. No. 4055, trans. Aug. 10, 1927; Aug. 2, 1927, many larvae nearing trans. N. Y. S. M. No. 3927–28; Aug. 10, 1927, 8 just trans.; Mar. 25, 1928, 2♂, 2♀ on ice in 2–4 inches of water; two females depositing eggs, two males each with three or four females (S. C. B. and D. Cook); Mar. 26, 1928, 8♀ (W. J. S.); Apr. 3, 1928, females laying eggs in ice-covered pond (W. J. S.); Apr. 5, 1928, sev. in pond (W. J. S.). *Berne,* June 9, 1926, 1 ad. (W. J. S. and C. Kilfoyle). *New Salem,* Apr. 14, 1923, 1 ad. N. Y. S. M. No. 9486; May 6, 1923, ad. N. Y. S. M. No. 9482; Apr. 5, 1924, juv. N. Y. S. M. No. 1480 (S. C. B. and W. J. S.); Mar. 26, 1925, 5 juv. (S. C. B. and W. J. S.); Apr. 13, 1926, 3 juv. (S. C. B., W. J. S. and H. H. Cleaves); Apr. 21, 1926, 1 ad. ♀ distended with eggs, under log. *Selkirk,* May 5, 1923, sev. ads.; June 1, 1924, 4 spec. (W. Peltz and J. Easton); May 15, 1925, 3 ads.; Jan. 20, 1933, 2♂, 3♀ (H. P. Chrisp, Betty Chrisp and W. L. L. Peltz); *Thacher Park,* May 8, 1928, eggs at point of hatching; Voorheesville, Nov. 4, 1922, 35 juv. and ads. N. Y. S. M. No. 9378–9413; Nov. 11, 1922, sev. ads.; Apr. 13, 1926, 1 juv. (S. C. B., W. J. S., and H. H. Cleaves). CATTARAUGUS: *Allegany State Park, Blacksnake mountain,* July 14, 1927, 1 ad. (Bishop, 1927); *Pickup pond,* July 1931, larva (Homer Jack). CHAUTAUQUA: *Poland Center,* July 8, 1937, juv.; Aug. 31, 1937, juv., Sept. 2, 1937, 1 juv. U. R. No. 4205; Sept. 12, 1937, juv. & ads. CORTLAND: *Chicago bogs,* 1922–1925 (Leffingwell, 1926). DUTCHESS: *Red Hook,* Aug. 27, 1938 (Van Auken). ERIE: *Buffalo,* Mar. 29, 1907, ads. (A. A. Allen); *Hamburg,* Apr. 7, 1909 (Wright, 1909); Apr. 8, 1910, larvae, C. U.; Mar. 28, 1910, ♀ and eggs; spring 1925, 3 ads. 1 juv. many eggs (R. R. Humphrey); *New Scranton,* Mar. 26, 1910, C. U.; *Tonawanda,* Oct. 30, 1926, 1 ad. (W. P. Alexander). ESSEX: *Essex Co.* (Baird, 1850); *Paradox lake,* June to Sept. 1926 (Weber, 1928). GENESEE: *Batavia,* June 18, 1916, 2 ads., 1 juv. A. M. N. H. No. 4027–28, 16808 (W. T. Davis); ads. (Wright and Moesel, 1919); *Bergen swamp,* June 8, 1929, 1 ad. (S. C. B. and E. Hilfiker). HAMILTON: *5th Lake Fulton Chain,* Sept. 14, 1916, A. M. N. H. No. 5122 (R. Minor). JEFFERSON: *Somerville* (Dunn, 1918). LIVINGS-

TON: *Caledonia, Log pond,* May 5, 1929, 15 spec. (W. Pierson). MONROE: *Mendon Ponds Park,* Oct. 3, 1929, 1 ad., 1 juv.; Oct. 1930, 1 ad. (P. R. Needham); May 5, 1932, 2 ads. (R. Redman); Apr. 13, 1933, 6 ads., eggs (E. A. Maynard); Apr. 19, 1934, 1 ad. ♀ and eggs (E. A. Maynard); Apr. 10, 1935, 3 ads., 3 juv. (E. A. Maynard); Apr. 13, 1937, ads. (E. A. Maynard); *North Chili,* Oct. 18, 1931, ads. and juv. U. R. No. 2158–60 (A. B. Klots); Oct. 21, 1931, 1 ad. sev. juv. U. R. No. 2181; Sept. 21, 1932, 5 ads. 1 juv. (S. C. B. and J. A. W.); Oct. 6, 1933, 2 ads., 1 juv., U. R. No. 3261; *Parma,* Mar. 29, 1929, 1 ad. U. R. No. 2232 (E. Hilfiker); Apr. 19, 1935, many eggs (L. G. Barth and S. C. Bishop); *Penfield,* Apr. 19, 1935, ad. & eggs; *Powder Mill Park,* Apr. 8, 1937, spermatophores and eggs; Apr. 11–12, 1937, ads., eggs, spermatophores; *Rochester,* May 20, 1930, 1 ad. U. R. No. 1306; Nov. 3, 1931, 1 ad. U. R. No. 2150 (K. Lagler); Dec. 11, 1931, 1 ad. U. R. No. 2131 (P. Stewart); Feb. 5, 1932, 5 spec. from sandbank, 3–4 inches below surface (J. B. Cole); U. R. Campus, Oct. 3, 1933, 1 spec., U. R. No. 3198; Oct. 18, 1933, 1 ad. (T. Forbes); Oct. 7, 1937, 1 ad., Oct. 21, 1938, 1 ad. (Cooper); *Spencerport,* Apr. 5–10, 1937, eggs, spermatophores and ads.; *West Henrietta,* Apr. 19, 1932, eggs (E. A. Maynard). NIAGARA: *North Tonawanda,* May 9, 1931, 1 ad. 6 juv., U. R. No. 1433-34 (J. Schofield); ONONDAGA: *Jamesville* road (Britcher, 1903); *Syracuse* (2½ mi. s.) Apr. 11, 1916, eggs (J. R. Slater); Apr. 13, 1916, ads. (J. R. Slater); (Wright and Moesel, 1919). ONTARIO: *Geneva* (E. H. Eaton); *Naples* (E. H. Eaton); *Woodville,* Canandaigua lake, Oct. 28, 1934, 1 ad. QUEENS: *Long Island,* 1880, 4 yg. ads., A. M. N. H. No. 2323–26 (N. Pike). RENSSELAER: *East Nassau,* Apr. 4, 1928, 9 ads., eggs (W. J. S.); *Melrose,* Apr. 25, 1926, eggs (H. H. Cleaves). ST LAWRENCE: *Black lake,* May 30th, 30 larvae, M. C. Z. No. 1860 (H. J. Perry). SARATOGA: *Saratoga lake,* May 3, 1922, 1 juv., A. M. N. H. No. 16,557 (C. S. Phelps); *Saratoga Springs,* Sept. 24, 1928, 1 ad. U. R. No. 836 (O. P. Phelps). SUFFOLK: *Calverton,* Peconic river, June 7, 1932, 1 ad. (R. Latham); *East Hampton,* June 8, 1932, 1 ad. (R. Latham); *Montauk,* May 31, 1913, 1st L. I. record (Engelhardt, 1914); Aug. 26, 1917, 3 yg. ads., A. M. N. H. No. 16805–7 (Engelhardt, 1917); May 11, 1928, 1 juv. (R. Latham); May 28, 1930, 1 juv. (R. Latham); Apr. 19, 1931, 1 4-in. spec. (R. Latham); Mar. 31, 1932, 2♂, 3♀ (Kumpf and Yeaton, 1932); Apr. 10, 1932, 2♂, 3♀ (Kumpf and Yeaton, 1932); *Montauk Point,* May 1930, 2 spec. (R. Latham); *Sag Harbor,* June 9, 1932, 1 juv. (R. Latham). TOMPKINS: *Forest Home,* Ithaca, July 9, 1923, C. U.; *McLean bogs,* 1922, 1 ad., 1 larva (Leffingwell, 1926); July 16, 1924, 2 ads.; between *McLean* and *Chicago bogs,* June 3, 1915, C. U.; 1922–25, larvae (Leffingwell, 1926); *Slaughter House pond,* Ithaca, July 9, 1923, C. U.; *Woodwardia swamp,* Oct. 19, 1924, 1 ad. (E. Crosby). ULSTER: *Ashokan,* Aug. 21, 1909, 1 ad., A. M. N. H. No. 2322. WAYNE: *Clyde,* Aug. 14, 1923, 1 ad., N. Y. S. M. No. 9519; *Duck lake* (Wright and Moesel, 1919). WESTCHESTER: *Silver Lake Park, White Plains* (Deckert, 1914).

Records too indefinite to be included under counties: Northern district of the State (DeKay, 1842); New York, type of *Salamandra granulata* DeKay, U. S. N. M. No. 3989 (Cope, 1867, 1889), (Allen, 1869); 2 ads. U. S. N. M. No. 3981 (Yarrow, 1882); possibly throughout the State (Eckel and Paulmier, 1902); Oneida lake, June 25, 1916, 1 ad. R. S. No. 439 (T. L. Hankinson).

Condensed Bibliography

Life history and habits. Clanton, 1934, p. 1–14 (*Ambystoma jeffersonianum*); Kumpf and Yeaton, 1932, p. 1–7; Mohr, 1930, p. 50–55; Mohr, 1931, p. 102–104; Piersol, 1910, p. 732–738; Piersol, 1929, p. 57–74; Smith, 1911, p. 14–27 (*Amblystoma jeffersonianum*); Wright, 1908, p. 286.

Distribution in New York. Allen, 1869, p. 202 (*Salamandra granulata*); Baird, 1850, p. 288 (*Salamandra jeffersoniana*); Bishop, 1923, p. 64 (*Ambystoma jeffersonianum*); Bishop, 1927, p. 118; Britcher, 1903, p. 120

(*Amblystoma jeffersonianum*); Cope, 1867, p. 197; Cope, 1889, p. 89; Deckert, 1914; DeKay, 1842, p. 78 (*Salamandra granulata*); Dunn, 1918, p. 458 (*Ambystoma jeffersonianum*); Engelhardt, 1913, p. 3 (*Amblystoma jeffersonianum*); Engelhardt, 1914 (*Ambystoma jeffersonianum*); Engelhardt, 1917, p. 98 (*Amblystoma jeffersonianum*); Eckel and Paulmier, 1902, p. 399; Green, 1827, p. 4 (*Salamandra Jeffersoniana*); Holbrook, 1842, p. 51 (*Salamandra jeffersoniana*); Kumpf and Yeaton, 1932, p. 1 (*Ambystoma jeffersonianum*); Leffingwell, 1926, p. 72; Wright, 1908, p. 286 (*Amblystoma jeffersonianum*); Wright, 1918, p. 56 (*Ambystoma jeffersonianum*); Wright and Moesel, 1919, p. 63; Yarrow, 1882, p. 150 (*Amblystoma jeffersonianum*).

AMBYSTOMA MACULATUM (Shaw)

(*Lacerta maculata*, Gen. Zool., 1802, 3:304)

Spotted Salamander

Figures *2e*, *4e*, *23–25*, *26d–f*, *27*

The spotted salamander is generally distributed throughout the State and, because of its large size and conspicuous markings, is probably recorded more often than any other species of *Ambystoma*. Except at the egg-laying season, I have never found it so abundant as the Jefferson salamander for it seems to lack the social instinct which brings so many young individuals of that species together in the fall and again in the spring.

Description

Size. The spotted salamander is intermediate in size between *Ambystoma jeffersonianum* and *Ambystoma tigrinum*. Thirty males taken in the breeding season average 175.5 mm in length (6⅞ inches) and vary from 150 to 196 mm (5 15/16 to 7¾ inches). In five specimens the tail slightly exceeds one-half the total length; in one specimen the tail is just half the total length; and in 24 specimens is slightly less than the total length. The variation in tail length ranges from 46.8 to 50.7 per cent of the total length.

The females are a little smaller than the males. Twelve breeding females average 169.7 mm (6 11/16 inches).

Form. The body is somewhat depressed, particularly in the females. The snout is broadly rounded to the eyes and less depressed than in *A. jeffersonianum*. The sides of the head back of the angle of the mouth are often strongly developed. The neck is broad but marked off from the head by the vertical extensions of the gular fold which meet, on each side, a longitudinal fold running to the eyes. The costal grooves are variable in number but in the majority of specimens, when axial and inguinal are counted, there are twelve. Individual specimens may have 11 or 13 or the

Fig. 23 *Ambystoma maculatum.* Young male, Rochester, N. Y. H. P. C., del.

Fig. 24 Hill-top pond at Albany, N. Y., breeding place for the spotted salamander, *Ambystoma maculatum* and the Jefferson salamander, *Ambystoma jeffersonianum*. E. J. S. photo.

count may be 11–12 or 12–13 on the two sides of a single specimen. The legs are large and strong. There are four toes on the front feet, of which the first is the shortest, the others in order of length 4-2-3; the hind feet have five toes, the first shortest and the others in order of length, 5-2-3-4. The openings of the slime glands are largest and most abundant on the tail but they are present on the back and on the sides of the upper surface of the head where they are somewhat enlarged. The tail possesses no definite constriction but is marked by impressed vertical lines variable in number.

The vomerine teeth are in a transverse sinuous line which may be continuous or slightly interrupted at the middle point and back of the inner nares. In certain specimens there may be a wide break back of the inner nares and rarely the series may be complete on one side and broken on the other.

The tongue is broad and fleshy, free only at the margin and provided with distinct plicae which, in general, radiate from the posterior part. Where the tongue narrows behind this area the surface is finely rugose.

Color. The color above is a deep bluish black. The lower half of the sides, the venter and under surfaces of the limbs are lighter, dusky slate color. Standing out in strong contrast against this dark ground color are rounded spots varying from dull greenish yellow to brilliant orange, disposed in two rather irregular rows, one on either side of the middorsal line of the head, trunk and tail. On the average there are six spots on the head, but the number varies from four to nine. On the trunk the spots vary from 13 to 20 or more with the average about 17. The greatest variation is to be found in the spotting of the tail. Here there may be as many as 19 spots or as few as six and in 12 specimens the average was 11. The total number of spots on the same 12 individuals ranges from 24 to 45.

During the season when the adults are in the breeding ponds, the venters of the females are somewhat lighter, pale slate color, while the males seem to have their general color heightened and the spots brighter. In some individuals the spots on the head have a reddish tinge. Corrington (1931, p. 77) mentions a specimen from near Fayetteville, N. Y., which was deep uniform black dorsally, the dorsal spots being almost entirely lost.

Sexual differences. The male is slightly more slender than the female and in the breeding season may be recognized at once by the greatly swollen and very protuberant vent. The females at this

season have the venter lighter than the males, usually pale slate in color.

Other differences which are apparently constant and serve to distinguish the sexes at any season of the year are to be found in the body proportions. In males and females of the same length the head of the female is somewhat broader, more convex above and widest at about the angle of the jaws. Behind this point the sides of the head taper to the vertical extension of the gular folds and in front of this point the sides are broadly rounded to the blunt snout. In the male the sides of the head behind the angle of the jaws are nearly parallel and in front the sides converge to the more pointed snout.

In the female the distance between the fore and hind legs goes into the total length only 3.6 to 3.8 times while in the male this variation is from 4 to 4.5. In the female the toes of the appressed limbs are separated by the width of two to three costal interspaces while in the male the toe tips may touch or be separated by not more than one costal interspace.

In this species the legs of the male are not greatly enlarged or noticeably longer than in the female, a distinction quite evident in *A. jeffersonianum*. The tail of the male spotted salamander is usually longer, more slender, and less deep than that of the female.

Comparative measurement of two individuals of the same length exhibit differences as follows:

	TOTAL LENGTH	DISTANCE BETWEEN LEGS	TAIL	DISTANCE BETWEEN TOES OF APPRESSED LIMBS	WIDTH OF HEAD AT ANGLE OF JAW	WIDTH AT REAR OF HEAD	LENGTH OF VENT
♂	187 mm	42 mm	90 mm	4 mm	15 mm	15 mm	12 mm
♀	187 mm	52 mm	84.5 mm	12 mm	18 mm	12 mm	9 mm

Sexual differences are apparently not expressed in the size of the orange spots or their arrangement, and the average in a considerable number of both sexes is essentially the same. There is, however, a tendency toward greater uniformity in the number of spots on the males, a fact which may have some significance. In a series of large males the number of spots varied from 30 to 38 while in an equal number of females the range was from 24 to 45. A few spots, usually smaller, are present on the upper surface of the legs. The spots are brighter during the breeding season and often fade to dull yellow at other times of the year. In alcohol they fade in time to dull white and the ground color is slate above and light gray on the lower sides and venter.

Activities of the Breeding Season

Migration. The migration of adults to the breeding ponds in the spring normally takes place at night, beginning soon after dark and sometimes continuing until dawn if suitable conditions are maintained. Although release from hibernation may take place at essentially the same time and under the conditions that govern the activities of the Jefferson salamander, the spotted salamander rarely reaches the breeding waters as early as that species. Several factors may be involved: (1) the spotted salamander may travel at a slower pace than its relative, (2) the spotted salamander often travels much farther from the breeding waters and thus has a greater distance to cover on the return, and the Jefferson salamander, on the other hand, frequently spends the winter within a few feet of the ponds in which it will deposit its eggs, (3) the spotted salamander frequently pauses on its journey and makes an overnight stay under convenient cover even though conditions might permit the continuance of the trip.

The spotted salamander is usually preceded by *A. jeffersonianum* by two or three days and sometimes by as much as a week, and the males are normally one or two days in advance of the females. In 1923, for example, *A. maculatum* males appeared at the ponds April 3d and deposited spermatophores on April 5th, the date which marked the first appearance of the eggs of *A. jeffersonianum.* Females of *A. maculatum* were present April 5th and deposited eggs April 9th.

Since humidity and temperature largely govern the migratory movements of these salamanders, it follows that those within a short distance of the ponds may reach them the first night. Those having greater distances to travel may take several nights even if favorable conditions persist or as much as two weeks or longer in the event that cold weather interrupts.

Blanchard (1930, p. 154) has given consideration to the stimuli involved in the breeding migration of the spotted salamander and in summarizing his data for 1927 was able to present the theory that, "These salamanders migrate to the breeding pond (1) almost exclusively at night, (2) only when the temperature is above freezing and (3) only during a rain." Applying his theory to his own data covering other years and to data accumulated by other writers, Blanchard demonstrated rather convincingly that humidity and not temperature alone was the important stimulus to the breeding migration.

I would qualify this theory by adding that, in eastern New York, migration of this species and *A. jeffersonianum* may be initiated by rains during the day and even by the rapid run-off of snow water following a pronounced rise in temperature.

In a later paragraph will be found a table giving dates of first appearance of spermatophores and eggs of this species covering a period of several years. The first appearance of spermatophores does not ordinarily mark the earliest date of arrival of adults to the ponds, and the only way to establish this point is to encounter the salamanders in migration. Wright (1908, p. 285, 287), who studied the species in the Ithaca region under exceptionally favorable circumstances, found that sometimes a day or two elapsed between the arrival of the males to the breeding marsh and the first appearance of spermatophores. This is perhaps to be expected in view of the fact that the females are ordinarily a day or two later than the males in arriving at the ponds and that the males usually deposit spermatophores only in the presence of females. Blanchard (1930, p. 158) also indicates that on several occasions the spermatophores appeared the day following the first recorded appearance of the males.

Wright (1908, p. 285, 287) has summarized his data for the Ithaca, N. Y. region in two tables which I have combined below to indicate the first appearance of adults in the spring, the first eggs and the interval between first appearance and deposition of eggs.

YEAR	FIRST APPEARANCE	FIRST EGGS	INTERVAL (DAYS)
1900	April 6	April 6	0
1901	April 13	April 13	0
1902	March 25	March 28	3
1903	March 13	March 20	7
1904	April 1	April 5	4
1905	April 1	April 11	10
1906	March 28	April 14	17
1907	March 24	March 30	6

The latest date for fresh eggs in the Ithaca region was April 30, 1907, and for fresh spermatophores April 27, 1907.

My own records covering the five-year period from 1923 to 1927 are based on observation made in the vicinity of Albany, N. Y.

YEAR	FIRST APPEARANCE	FIRST SPERMATOPHORES	INTERVAL (DAYS)	FIRST EGGS	INTERVAL (DAYS)
1923	April 3	April 5	2	April 9	6
1924	April 4	April 5	1	April 5	1
1925	March 27	March 27	0	April 1	5
1926	April 8	April 9	1	April 13	5
1927	March 18	March 22	4	March 24	6

Maximum and minimum temperatures and precipitation for these dates were as follows:

YEAR		PRECIPITATION	MAX. TEMP. (F.)	MIN. TEMP. (F.)
1923	April 3	Trace	59	41
	April 5	1.02	48	36
	April 9	0	44	29
1924	April 4	0	59	32
	April 5	0	62	40
1925	March 27	.51	68	41
	April 1	.10	44	38
1926	April 8	.75	44	38
	April 9	0	52	37
	April 13	0	55	26
1927	March 18	.18	65	46
	March 22	0	41	27
	March 24	0	38	24

It will be noted that, with the exception of 1924, rainfall of greater or less amount coincided with the first appearance of the salamanders in migration. On April 3, 1923, sufficient rain fell between 6.15–8.25 p.m. and 11–12 p.m. to start the migration of this species. On the following day and night rain fell at intervals and induced further migration and active mating in the ponds. On April 5th between the hours of 3.09 p.m. and 9.30 p.m. there was a downpour of 1.02 inches accompanied by active migration and mating activities.

In 1924 on April 4th, when the first salamanders appeared, there was no precipitation. On April 1st and 2d, however, 11 inches of snow had fallen which, by 8 p.m. on April 2d, was reduced to 5½ inches on the ground and 24 hours later only one-half inch remained. At 8 p.m. of April 4th the snow had entirely disappeared and the salamanders were in migration. It thus appears evident that the rapid run-off of snow water in considerable amounts may serve as effectively in initiating migration as rainfall, provided the temperature at night does not go below freezing.

Mating. Preceding the deposition of spermatophores or accompanying this operation, individuals of both sexes sometimes congregate in large numbers in limited areas of the breeding ponds and participate in a kind of nuptial dance. They swim around, over and under one another rubbing and nosing together vigorously, their exertions and excitement fairly making the water boil and the continual breaking of the surface as they rise to take in air adding to the illusion of bubbling water.

Breder (1927, p. 51) reports such an assembly during the night of April 6, 1926. In one small woodland pool five distinct aggregations were observed each made up of 40 to 50 individuals, the sexes about numerically equal. In the spring of 1927 at Cold Spring Harbor, N. Y., the assembly was again observed by Mr and Mrs Rudyerd Boulton, who reported that the males greatly outnumbered the females. (Breder, *id.* p. 53). In Powder Mill Park, Monroe county, N. Y., the nuptial dance was observed on the night of March 30, 1939, the males predominating.

The conditions which serve to bring together such a vast number at the same time and place are not every year present. Such assemblages have taken place during prolonged rains which permitted many individuals to reach the breeding ponds at essentially the same time, the late arrivals joining the groups already organized and prolonging the activities by their participation.

In areas where only a limited number of individuals congregate, the mating activities may be engaged in by so few individuals that the spectacular features of the nuptial dance are lacking. On the other hand, observations on the activities of individuals are much more easily made.

Preliminary to the deposition of spermatophores, the male noses the female. Wright and Allen (1909, p. 690) describe the process as follows:

> It seemed to be the object of the male to bring the top of his head in contact with the venter of the female. The throat region of the female seemed to be preferred, although he often began in the cloacal region or even at the tip of the tail and rubbed the dorso-lateral part of the head along her whole ventral side. After each performance of this kind, the male swam away and grasped one of the sticks with its hind legs, bringing the cloaca close to the stem. The tail quivered for a moment and, with an arching of the region just caudad of the cloaca, the vent was lifted from the spermatophore. Then, he immediately returned to the female and began again the "nosing" process.

During these operations the female usually remains passive, but when sufficiently stimulated she moves forward, covers the spermatophore with the vent and, with the hind limbs closed about it, either rests quietly in that position without attempting to take up the spermatophore or by spreading the lips of the vent takes the cap into the cloaca.

Spermatophores. The spermatophores are vase-shaped or stump-shaped masses of clear jelly, each provided with a flattened

flangelike base and capped with a white, flocculent seminal mass. Often the seminal fluid spreads over the supporting jelly giving it a milky white appearance.

The spermatophores vary in height from one-fourth to one-half of an inch and may be either simple, branched or compound with two or more superimposed. Smith (1910, p. 204) has described in detail the structure of both spermatophores and spermatozoa.

They are deposited in shallow water in groups which may contain only two or three or they may occupy an area two or three feet across and number 100 or more. The average number in a group, and presumably the complement of a single male, is about 40. Wright and Allen (1909, p. 87) observed the deposition of 22 spermatophores by a single male, the procedure lasting 45 minutes. From three to 16 seconds were consumed in depositing a single spermatophore.

Usually the spermatophores are deposited only in the presence of females and following a rubbing and nosing operation in which each sex apparently receives the necessary stimulus.

Frequently, when spermatophores appear to be deposited in linear series on the pond bottom, it will be found that the male has straddled a water-soaked branch and attached the spermatophores at fairly regular intervals.

The egg-laying process. The deposition of eggs under natural conditions was observed on the night of April 14, 1926, in a small pond on the outskirts of Albany, N. Y. Two females were watched and each had chosen a slanting stick as a support for the eggs. The stick in each instance was grasped about six inches below the surface of the water, the hind legs only being employed. The body was held almost erect with the tail dropping below the branch and the fore legs widely spread. The eggs appeared slowly one after another and were applied to the upper side of the branch. The females occupied essentially the same position throughout the process and did not attempt to spread the eggs along the branch as the Jefferson salamander so frequently does. The mass when first deposited, in spite of the large number of eggs present, is comparatively small, often less than an inch in diameter, but rapidly swells and partially or completely surrounds the support.

These observations confirm those made much earlier by Wright (1908, p. 287–88). On March 30, 1907, Wright found near Ithaca, N. Y., three different females in egg-laying position. He states:

All three females were laying at one time, and two of the three were simultaneously depositing upon two closely apposed stems of

smartweed, the vent of the lower one being about an inch below that of the other. One female held on with both hind and fore limbs, her head was appressed to the side of the stem. The second female was facing the first, her vent being slightly lower. She grasped the stem only by her hind limbs, was semi-erect and inclined diagonally to the side. The stems were so small and close together, that had the second desired it she could not have clasped the stem with her fore limbs without embracing the first female. In both the tail extended diagonally downward, no prehensile tendencies being noted in any of the three.

The first female after about a minute disengaged herself and swam off. The second after a short time, did the same but was captured. Both bunches of eggs were at this moment no more than one-half of an inch in diameter. In less than an hour they were two inches in diameter. The third female, only a foot away had not been disturbed by the sweeping of the net. She held on by her hind limbs only, leaving most of her body free. The bunch of eggs was only an inch from the top of the stem. This female was not perfectly erect but slightly arched.

The egg mass. The eggs are deposited in firm and compact masses which are usually more or less globular but sometimes oval or subquadrate. The mass may have a diameter of 2½ to 3½ inches when the eggs are in early stages of development but subsequent absorption and partial disintegration may greatly increase the size, one such distended mass measuring 4½ inches in diameter. When first deposited the mass is small, hardly more than one-half an inch in diameter, but within an hour or two the normal size is attained. The eggs are more closely aggregated than those of *A. jeffersonianum* and the average number to the mass much larger. A mass may contain as few as a dozen or 15 eggs but generally the number is nearer 100. Nine typical masses contained respectively 256, 159, 144, 124, 167, 101, 120, 75 and 61 eggs each. The full complement of a single female is usually deposited in two or three masses which may vary greatly in size and egg count. The total complement may number more than 200 eggs as determined not only by isolating single impregnated females but by counting the ovarian eggs. Wright and Allen (*id.*) found that at least 30 minutes was consumed in depositing a single mass, but the time was in some instances prolonged to over one hour. Often single eggs are dropped, each with its complete complement of envelops. The outermost jelly covering of the eggs of this salamander is much thicker than that of *A. jeffersonianum* and the outer surface smoother, for it does not follow the contour of the individual eggs. The jelly is so firm when freshly deposited that it will retain its

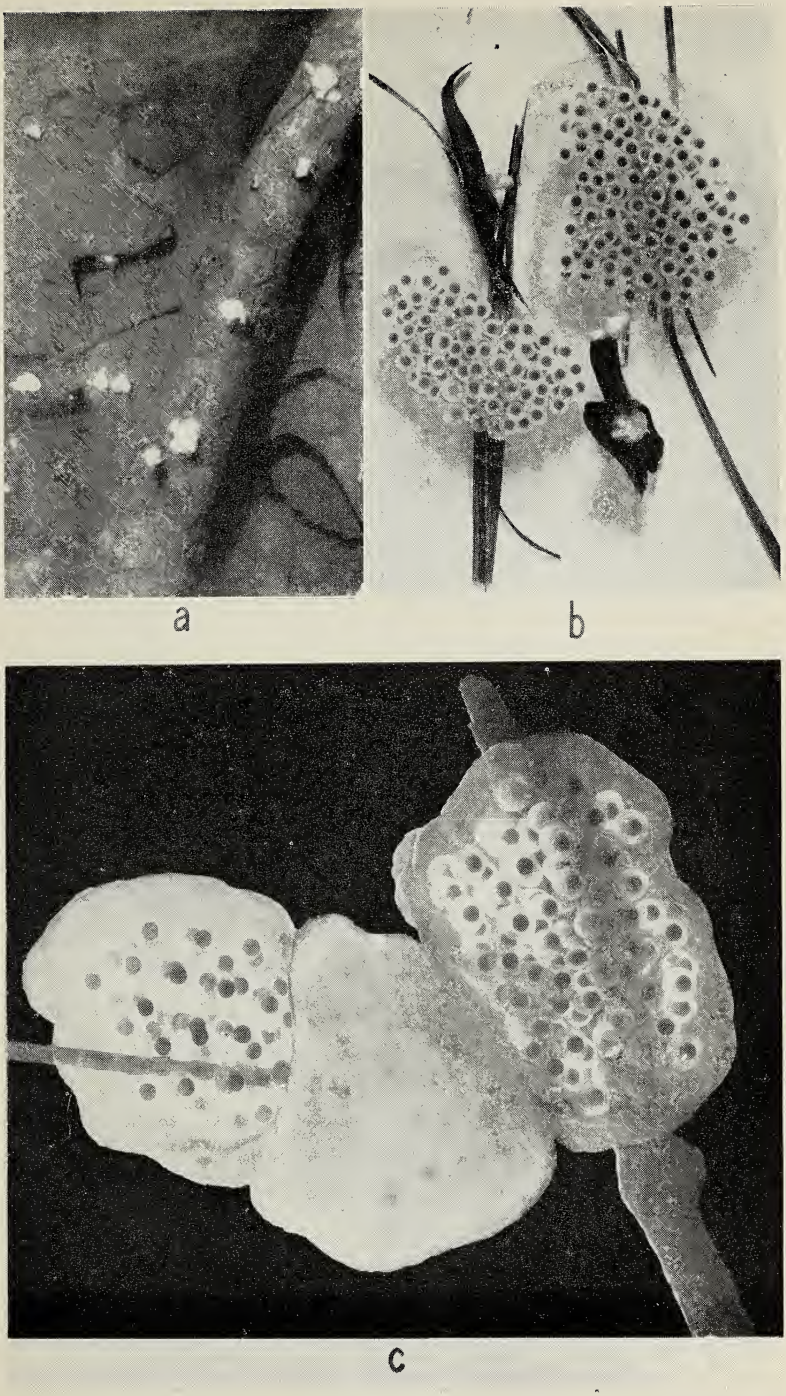


Fig. 25 a. Spermatophores of *Ambystoma maculatum* as they appear attached to leaves and sticks on the pond bottom. New Salem, N. Y., Apr. 14, 1924. b. Typical egg masses of *A. maculatum* with clear envelops, and two spermatophores on fragment of leaf. Albany, N. Y., Apr. 9, 1923. c. Three egg masses of *Ambystoma maculatum* attached to the same twig and exhibiting varying degrees of opaqueness of the envelops. Albany, N. Y., Apr. 22, 1926. c. photo by E. J. S.

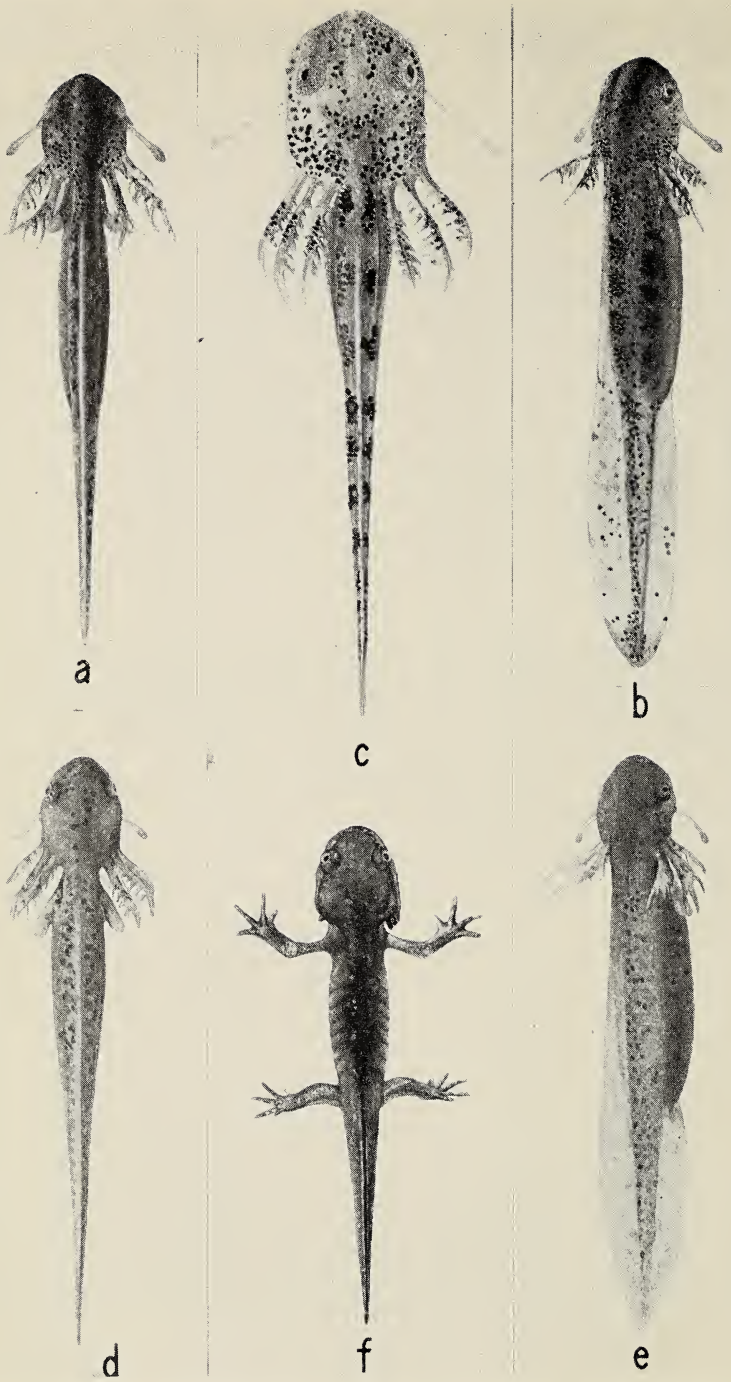


Fig. 26 *Ambystoma jeffersonianum.* a. Larva at hatching. Voorheesville, N. Y., Apr. 22, 1923. Actual length 12 mm. b. Same data, another individual. Actual length 14 mm. c. Same, larva four days old, kept over a light background. Albany, N. Y., Apr. 10, 1925. Actual length 15 mm. d. *Ambystoma maculatum.* Larva at hatching. Albany, N. Y., May 20, 1923. Actual length, 12.5 mm. e. Same, dorso-lateral view. f. Nearly transformed individual with greatly reduced gills. Actual length, 42.5 mm. S. C. B. and E. K. O'B., del.

shape when lifted from the water. Under the same circumstances the eggs of the Jefferson salamander will often slip from the supporting twig.

The egg mass is attached to sticks, weeds, grass, stems or reeds in quiet or slowly running waters and usually within eight or ten inches of the surface, occasionally much deeper. There is less care evidenced in the selection of a support than in the case of the Jefferson salamander which usually chooses a slender twig. The eggs may be attached to a vertical or horizontal support or hung from the drooping leaves of grasses, sedges or cat-tails.

Often the entire egg mass of this salamander is milky white and the individual eggs are all but invisible. The eggs in the center of these masses usually require more time for development than those near the outside, possibly because the white reflects the light and heat to a considerable extent. A single twig may support both clear and opaque masses, apparently, though not necessarily, deposited by the same female.

On April 10, 1928, at Albany, N. Y., a female *A. maculatum* deposited her eggs in a long string which had the superficial appearance of the eggs of a toad, Bufo. On the other hand, we found at Rochester, N. Y., (April 28, 1931) a toad, *Bufo americanus,* that had failed to supply her eggs with the outermost envelop and instead of being in long twisted strings, the eggs appeared singly.

Occasionally, the spotted salamander deposits eggs on land. Wright (1908, p. 289) mentions the discovery of several beneath logs and stones. Brimley (1921, p. 27) in his discussion of the species in the region about Raleigh, N. C., writes: "One lot of eggs found on February 22, 1905, deserves note, as instead of being laid in the water, they were laid among wet dead leaves lying just above the level of the water beneath a dead log which lay part in and part out of the water." Louise Smith (1921, p. 41) records a similar occurrence at Mount Toby, Sunderland, Mass. The eggs were under a plank in the boggy region above a small pond, April 9, 1921. Like those described by Brimley, the eggs were separate and the capsule of each was swollen and irregular.

Development

The egg and its envelops. The following description takes into account only the principal layers ordinarily visible in the fresh egg under low magnification. Piersol (1929, p. 71) has given a detailed account of the egg envelops and their subdivisions of both *A. maculatum* and *A. jeffersonianum,* comparing them in opposite columns.

The egg itself is 2½ to 3 mm in diameter. The envelops surrounding it are disposed as follows: a tenuous, vitelline membrane is closely appressed to the egg; second, there is a thin, pearly, envelop containing a little fluid in which the egg floats; third, a rather thick and tough envelop in contact with the second one. When the egg has a diameter of 2½ mm the diameter of the second envelop is about 5 mm and the third one about 6 mm. As before mentioned, the eggs are aggregated by a jelly covering of considerable thickness which is composed of the fused outer or fourth layers. The second envelop which is commonly milky in this species, is also pearly in some of the eggs of *A. jeffersonianum,* but to a less degree.

The animal pole of the egg is dark brown or gray, somewhat lighter than in the eggs of the Jefferson salamander and the pigment covers less of the surface. The lower pole is dingy white or yellow.

In the eggs of both *A. jeffersonianum* and *A. maculatum* the second envelop, that is, the inner one if the vitellus is disregarded, supports an algal growth which often almost obscures the embryo. This alga was identified by Dr Gilbert M. Smith of the Department of Botany, University of Wisconsin, as a species, probably new, of *Palmodactylon.* The color is a brilliant green and gives the envelop the appearance of a gigantic *Volvox,* particularly after the escape of the embryo. In the eggs of the spotted salamander from many parts of New York State the alga has developed if the embryos have been kept alive. There is perhaps a commensal relation in this association, the embryo contributing carbon dioxide and receiving oxygen in the photosynthetic process. Henry Orr (1889, p. 296) in his Note on the Development of Amphibians, mentions the occurrence of green algae in the eggs of an undetermined species of *Ambystoma* from Princeton, N. J., the earliest record of the alga-egg association I have encountered. The presence of algae within the egg envelops of *Dicamptodon ensatus* is reported by Storer (1925, p. 83). Breder (1927, p. 55) in discussing the eggs of *A. maculatum* also suggests the possibility of a commensal relationship and reports that eggs kept in the dark failed to develop. This may indicate that in the absence of photosynthesis the embryo fails to receive sufficient oxygen to survive. The presence of algae has also been noted by Cochran (1930, p. 186).

The period of incubation. In 1923 the first eggs were deposited April 9th and fresh eggs appeared from time to time until April 23d. Those first deposited hatched May 19th–21st, a period covering 40–42 days; those last deposited began to hatch May 24th and con-

tinued through June 4th, in this instance, the period covering 31–42 days.

To determine if eggs in masses in which the jelly was opaque hatched as rapidly as those in clear jelly, several lots of each were taken on April 12th. Those in clear jelly hatched at room temperature in 22 or 23 days. Eggs in the opaque masses began to hatch as early as those in the clear jelly but the process was continued ten days longer in the case of the former. It is probable that the eggs nearest the surface hatched first and those in the center of the mass, away from the light, last. Eggs tagged for identification and left in the ponds hatched in forty days as against twenty-two days in the laboratory. The length of the period varies greatly from year to year according to the character of the season.

In 1924 the first egg mass of the season appeared on April 5th but the season opened in earnest on April 12th. The eggs first deposited began to hatch May 19th, or 44 days after deposition. The bulk of the eggs deposited April 12th continued to hatch until June 5th, a period covering 54 days.

In 1925 the first eggs of the season were laid the night of April 1st and hatched May 15th–18th, or in 45 to 48 days.

The season of 1926 started later, April 13th, but the eggs hatched May 22d, an incubation period of only 39 days. In 1927 this period was extended to 50 days, the eggs appearing March 24th and hatching May 13th.

The latest date I have found fresh eggs in the Albany region was May 8, 1928, when a single mass was seen in a pond in Thacher Park, Helderberg mountains.

The newly hatched larva. Larvae on hatching have a length of from 12 to 13 mm. The body is slender and delicately molded. The ground color is dull greenish yellow with darker areas of olive on the head. Small rounded black pigment spots are present, most numerous on the head and tending to form longitudinal bands on each side of the mid-line of the back. On the upper sides below these dorsal bands, which are by no means conspicuously developed, there is an area comparatively free from pigment and below this another band lightly pigmented. This arrangement is not found uniformly developed in all larvae but often enough to warrant some attention.

Irregular spots of yellow pigment are scattered among small light gray spots on the tail fin and to a less extent on the body. There is scarcely a tendency towards segregation of the black pigment to

form conspicuous paired spots on each side of the middorsal line as in *A. jeffersonianum*. At the time of hatching, the gills, eyes and balancers are well developed. The front legs are represented by elongate buds without evidence of toes. The gills are provided with a double fringe of flattened filaments and at hatching are as long as the head. The middle pair is longest and the tips reach to the end of the leg buds. The tail fin is broad and continued over the back almost to the insertion of the front legs. It is widest just back of the vent and from that point tapers rather abruptly to the tip. The balancers persist for a period of from seven to ten days and are dropped when the larvae attain a length of about 16 mm. If, for any reason, the embryos are retained longer than usual in the eggs, as is sometimes the case when the jelly mass is opaque, the balancers may be lost in five or six days after hatching.

Length of larval period. In 1927 an attempt was made to determine accurately the length of the larval period in ponds at Albany, Thacher Park in the Helderberg mountains, and East Nassau, Rensselaer county. The pond in Thacher Park lies at an elevation about 1000 feet above that of the Albany pond and the season is usually from a week to ten days later. In Albany ponds the eggs began to hatch May 13th and, as usual, continued during the following ten days or two weeks. In the Helderbergs hatching was delayed until about May 23d. The table below summarizes the records for 1927.

LOCALITY	HATCHED	TRANSFORMED	AVERAGE LENGTH	EXTREMES	LENGTH OF LARVAL PERIOD (DAYS)
Albany.....	May 13–20	July 13–Aug. 15	43.4 mm	37–51 mm	61–94
East Nassau...	May 18	Aug. 12–27	58.4 mm	53–63 mm	86–101
Thacher Park..	May 23	Aug. 31–Sept. 13	52.8 mm	46–58 mm	100–13

The individuals transformed from the Albany pond are below the usual average in length because of the shrinking of the ponds in July. A number were transferred to the laboratory where they did not receive as much food as under pond conditions.

Records from Ann Arbor, Mich., presented by Dempster (1930, p. 184) for the years 1928–29 compare favorably with those from New York.

LOCALITY	EGGS LAID	HATCHED	TRANSFORMED	AVERAGE LENGTH	LENGTH OF LARVAL PERIOD
Delhi Pond...	Apr. 3, 1928	.....	Aug. 18	Approx. 60 mm	.....
Delhi Pond...	Mar. 27, 1929	May 11	Aug. 14	48.92 mm	95 days

The earliest date at which transforming individuals were found was July 13, 1927, at Albany. Individuals from a cold hillside spring near Stephentown, Rensselaer county, N. Y., transformed October 17, 1922, the latest date in my records.

In 1924 at Albany, the minimum period of development from egg-laying to transformation was 112 days. In 1927 this period was extended to 160–73 days. At Ann Arbor, Mich., in 1928, the length of this period was 137 days and in 1929, 141 days.

The mature larvae. The mature larvae vary in length from 40 to 72 mm with the average about 51 mm. The size at which the species transforms may vary from year to year and is dependent, in part at least, upon conditions in the breeding ponds, whether or not the ponds are drying, abundance of food and water temperature.

A series of specimens from a drying pond, taken August 7, 1927, at Albany, N. Y., averaged only 45.3 mm with extremes of 40 and 50 mm. A similar series taken July 3, 1926, from the same pond averaged 51.2 mm with extremes of 43 and 56 mm.

The head is broad, widest just in front of the gills, and gently rounded to the blunt snout. The body is slender and tapers uniformly from about the fourth or fifth costal groove to the tip of the tail. The color above is generally dark brown, but becomes lighter on the sides of the head below the eyes. The legs are light at the point of attachment and strongly flecked with yellow and black pigment. The dorsal keel originates at a point above the insertion of the fore legs and is gray mottled with yellow except on the distal half where it is more uniformly gray or brown. The sides of the trunk are marked with small light spots, yellow or greenish yellow, sometimes apparently irregularly disposed but in others arranged in fairly regular lines in about the position later occupied by the large yellow or orange spots of the adult. The gills are brown with the filaments a little lighter. This description applies particularly to individuals taken from a small stagnant pond containing little plant growth.

In another lot of mature larvae the color pattern was quite uniformly as follows: The ground color above is dark greenish or yellowish gray. On each side a narrow line with irregular edges free from dark gray pigment and extending from the gills along the sides of the trunk onto the tail where it becomes broken into a series of small, irregular wormlike markings, or spots. This light line is not at all conspicuous but is perfectly evident under the hand lens. Below the light line, the sides have a bluish cast, somewhat irides-

cent. The head has a dark central area and a dark spot in front of each eye. The tail and feet are strongly mottled, yellow and gray in irregular patches, a pattern quite different from that of *A. jeffersonianum*. The belly is iridescent and the throat white. The lips are slightly pigmented below. The pupil of the eye is black and there is a narrow yellow line on the iris next to the pupil, the outer parts being pigmented.

Larvae may lose the gills completely before leaving the water and acquire a considerable amount of yellow on the back and sides.

As the measurements given above indicate, larvae of *A. maculatum* may individually attain a size equal to or exceeding that of *A. jeffersonianum* but the average length is considerably less. It is also to be noted that the recently transformed average a little shorter than mature larvae, a difference which may be attributed to the absorption of the tail fin.

Transformation. In recently transformed individuals the ground color of the dorsal surface varies from dull dark brown through shades of gray to black. Greenish yellow pigment flecks, irregular in shape and size, are distributed over the surface of the head, trunk, legs and tail. The markings are lichen-like in appearance and not confined to the areas where they are later segregated. There is either a migration of the pigment cells and the fusion of closely adjoining ones or the spots characteristic of the adults arise independently and the earlier ones disappear.

On each side of the midline of the back there is sometimes an interrupted and indistinct line of fine gold points which may continue onto the tail. The legs are lighter at the base on the anterior sides and darkly mottled above. The belly and lower surface of the limbs vary from light flesh color to dull yellowish white; the lower surface of the tail is somewhat darker.

In specimens from dark, woodland pools the colors are darker and more uniform, with less indication of yellow pigment. Often these pools shrink early in the summer and only the larvae approaching transformation survive. These are ordinarily smaller than individuals from permanent ponds where often transformation is so long delayed that considerable yellow pigment is acquired before leaving the water.

Fully transformed individuals have been found in the Albany region as early as July 7th but transformation may continue in the colder waters until late in October. They may be only 42 mm long or attain a length of 70 mm; the average of a considerable number

being about 51 mm. The transformation from the fully aquatic larvae with large gills and broad tail fins to the terrestrial stage with well-developed spots takes place in a comparatively short time, the table below indicating the exact limits in the case of several individuals.

LARVAE WITH GILLS	LENGTH	GILLS REDUCED	GILLS LOST	SPOTS INDICATED	SPOTS WELL-DEVELOPED
Aug. 2, 1927...	42 mm	Aug. 8, ½ length	Aug. 14	Aug. 20	Aug. 26
Aug. 2, 1927...	50 mm	Aug. 8, short stubs	Aug. 10	.....	.....
Aug. 2, 1927...	41 mm	Aug. 10, ½ length	Aug. 20	.....	.....
1927.....	48 mm	Aug. 2, stubs.....	Aug. 4	Aug. 20	Aug. 26
Aug. 2, 1927...	50 mm	.....	Aug. 7	.....	Aug. 20
Aug. 2, 1927...	51 mm	.....	Aug. 9	.....	.....
Aug. 2, 1927...	47 mm	.....	Aug. 7	.....	Aug. 20
Aug. 22, 1927...	72 mm	Aug. 26.....	Sept. 1	.....	.....

Coincident with the loss of the gills, the toes become very much shortened in the spotted salamander while in the Jefferson salamander they remain long and slender although the tips of the toes become blunt.

A characteristic feature of the recently transformed individual is the broad, flat head which abruptly narrows to the slender trunk. The tail is slightly keeled above, the pupil of the eye is black and the iris gold. A narrow dark line extends through the eye to the nostril.

Development to maturity. Within a year following transformation the spotted salamander attains a length of about 82 mm. I have seen very few specimens of this age and they are not abundant in collections. Where adults during the breeding season may be exceedingly abundant and scattered individuals found at almost any season of the year, the half-grown specimens are more rarely discovered. I have never found them associated with the young of the year as in the case of *A. jeffersonianum,* nor do they often appear in the spring following the release from hibernation.

The spotted salamander is a fairly long-lived species. Pope (1919, p. 67) records the capture of an adult in April 1912 that was alive and thriving in August 1919. In October 1928 (Pope, 1928*a*, p. 99) Pope again referred to this specimen which was still alive at the advanced age of at least 18 years.

Habits

General. During the daylight hours of summer this species remains in hiding under logs and stones or buried beneath the surface of the ground both in clearings and open woods. If the breeding waters have been slow streams or ponds in the lowlands they often

seek higher situations for the period of hibernation. If, as is often the case, the breeding places are hilltop ponds they seek the somewhat drier situations to be found on wooded slopes. In October and November they are commonly on the move and even in December when the weather is mild they may be abroad. During the breeding season in the spring they almost invariably migrate by night whereas in the fall they are not infrequently found during the daylight hours, especially if some obstruction lies in the path of migration. During dark, rainy days they may sometimes be seen crossing the highways. They are often found in cellars and pits into which they have tumbled during their wanderings. As the nights become colder they bury themselves beneath the leaf mold or hide under stumps and rotting logs.

Spotted salamanders apparently do not congregate in numbers in the fall as is the habit of immature *A. jeffersonianum,* nor is it often that the young of the year are found with the adults. They are quite solitary in their habits and if several are found together it is because they have stumbled upon the same winter retreat. The breeding places in the spring are the centers of abundance for this species.

The spotted salamander is sometimes encountered deeply buried beneath the surface. At Shippan, Conn., a specimen was found at a depth of two feet below the surface when an excavation was made for the planting of shrubs. (Guide to Nature, 1927, p. 190.)

In the Ithaca region, Wright and Allen (1909, p. 687) report them common on the wooded hillsides bordering Cayuga lake, while the marshes at the head of the lake are favorite breeding places.

Food. Surface (1913, p. 89) examined 54 specimens of this species of which 31 contained food. He reports the following items as the most important in the diet: earthworms, snails, slugs, spiders, millipedes, crickets, ground beetles, rove beetles, ants and other insects. The food of this species studied in Onondaga county, N. Y., by J. R. Slater and reported on by Smallwood (1928, p. 90–91) consisted of the following: centipedes, earthworms, snails, ground beetles, stone crickets, grasshopper, scavenger beetle, "pill-bug," plant fragments and insect larvae. The larvae of salamanders are reported as taking stickle-backs, *Eucalia,* in considerable numbers during July and one larva only 1.75 inches long had taken two of the fish, 12 and 15 mm long, respectively. Smallwood also called attention to the absence of food in stomachs of this species during the spring migration and while the adults are in the breeding ponds and suggests that during this period they do not eat.

Habitat

Although this species has been encountered in habitats varying greatly in character, it seems to be most abundant in areas of deciduous woods where ponds, slow streams and temporary pools offer suitable breeding places. It is also abundant in mixed and deciduous forest areas but fewer are found in sections where the evergreens predominate. In the Albany region, the breeding ponds where I have studied the species are surrounded by or are near mixed stands of hardwoods and hemlocks. Sometimes the ponds are hilltop depressions that become dry late in the summer, often they lie deep in the woods as swampy holes filled with decaying leaves. At East Nassau the spotted salamander repairs to a sphagnum-bordered pond with a deep mucky bottom. In the Adirondacks, where I have encountered the eggs even in June, the pools bordering the old lumber roads or abandoned lumber railroads are favorite breeding places. On Long Island I have found the eggs in ponds near Syosset, where they shared the water and food with the newt, the tiger salamander and the marbled salamander.

During the summer they often wander a considerable distance from the breeding waters and have been found not only in the cellars and window wells of city houses but on mountain slopes high above the nearest pond or slow stream. The wandering habit seems to be more highly developed in this species than in *A. jeffersonianum* which, when conditions are suitable, often remains by the breeding ponds throughout the year. We have also found the spotted salamander on hillside meadows where the only shelters were stones and an occasional log, in creek bottoms under logs and pieces of bark and on one occasion near a small pond in the pine barrens west of Albany, N. Y.

In the various parts of their range in the East they are associated with a great variety of other species of amphibians. On Long Island we have found them in ponds that are shared with the *Ambystoma tigrinum, Ambystoma opacum, Triturus v. viridescens, Rana clamitans, Hyla versicolor, Hyla crucifer, Acris gryllus* and *Bufo fowleri.* At Albany the ponds to which they resort are occupied successively by *Ambystoma jeffersonianum, Hyla crucifer, Triturus v. viridescens, Rana sylvatica, Bufo americanus* and often *Rana clamitans* and *Rana pipiens.* In the New Salem swamps the pools harbor *Ambystoma jeffersonianum* and *Rana sylvatica* in numbers and the banks of sphagnum hide the four-toed salamander, *Hemidactylium scutatum.*

Remarks

Clarke (1880, p. 105) gave many of the essential features of the development and life history of the spotted salamander, including an account of egg laying, but he was apparently misled into thinking that fertilization was accomplished by the deposition of spermatic fluid over the eggs. Andrews (1897, p. 636) described the spermatophores and concluded that (*a*) fertilization was internal, (*b*) the spermatophores were deposited in advance of the egg laying and (*c*) that the spermatophores were subsequently taken up by the female, conjectures based on knowledge of other species of salamanders which subsequently proved to be correct.

Although many have observed the deposition of eggs by captive specimens, Wright (1908, p. 287) seems to have been the first to witness the process under natural conditions. Breder (1927, p. 54), apparently unaware of this earlier account, credits C. K. Urner with this distinction. Breder (*ibid.*), however, was the first to give a detailed account of the sexual congress involving many individuals and presented other interesting observations on habits.

Green (1827) seems to have been the first to record the species from the State.

Range. The spotted salamander has been recorded from Nova Scotia west to Wisconsin and southward to Georgia and Texas.

Fig. 27 New York localities for *Ambystoma maculatum*

Distribution in New York

General. Throughout the State in suitable localities except on the higher mountains.

Specific records. ALBANY: *Albany,* 1827 (Green, 1827); 1835 (Eights, 1835); May 4, 1904, 1 ad., N. Y. S. M. No. 71 (F. C. Paulmier); Branchipus pond, Albany, Apr. 4, 1923, spermatophores; Apr. 5, 1923, 1 ad. ♂; Apr. 6, 1923, 1 ad.; Apr. 10, 1923, eggs and spermatophores; Mar. 27, 1925, spermatophores; Apr. 1, 1925, eggs; Apr. 10, 1925, eggs, N. Y. S. M. No. 4767; Apr. 9, 1926, spermatophores; Apr. 10, 1926, 1 ad.♂, 1 ad.♀; Apr. 13, 1926, 5♂, 2♀, N. Y. S. M. No. 3043–45; Apr. 14, 1926, 4♂, 1♀ (B. S. B. and S. C. B.); Mar. 18, 1927, 10♂, 1♀, N. Y. S. M. No. 4747; Mar. 25, 1927, 1♀; Apr. 5, 1927, many ads. in pond (W. J. S.); Apr. 14, 1927, 5♂ (S. C. B. and J. L. Cooley); July 10, 1927, many larvae, N. Y. S. M. No. 4311; Aug. 2, 1927, mature larvae, N. Y. S. M. No. 3929, 3950, 4054; Aug. 10, 1927, mature larvae, N. Y. S. M. No. 3951; Aug. 12, 1927, larvae beneath leaves in drying pond; Aug. 12, 1927, just transformed, N. Y. S. M. No. 4109–4112; Apr. 10, 1928, eggs deposited in a long string like those of Bufo; Apr. 8, 1929, eggs (W. J. S.); *Alcove,* May 3, 1924, spermatophores; *Altamont,* Apr. 8, 1928, 1♀ (E. S. Whitbeck); *Medusa,* July 2, 1920, 1 ad., N. Y. S. M. No. 6893; *Mud Hollow pond,* June 20, 1923, 1 juv.; *New Salem,* Apr. 14, 1923, many eggs; *Thacher Park,* Oct. 4, 1924, 1 ad.; Aug. 31, 1927, 16 mature larvae, 1 just transformed, N. Y. S. M. No. 4302–4310; Sept. 3, 1927, 3 larvae, N. Y. S. M. No. 4299-4301; Sept. 13, 1927, mature larvae (S. C. B. and W. J. S.); May 8, 1928, freshly deposited eggs. ALLEGANY: 2 ads., U. S. N. M. No. 3930 (Stevens, col; Yarrow, 1882; Cope, 1867, 1889). CATTARAUGUS: *Allegany State Park,* June 9, 1933, 1 juv. (S. C. B., H. Chrisp, K. Lagler, C. Zorsch); Stony run, July 9, 1921, 2 juv., N. Y. S. M. No. 3329, 3332 (W. P. Alexander); Natural History School, May 7, 1938, eggs; Oct. 15, 1938, 2 ads. (C. U.); Mt Onondaga, Aug. 9, 1922, 1 ad., N. Y. S. M. No. 3326 (W. P. Alexander); Red House creek, Aug. 12, 1922, 1 juv., N. Y. S. M. No. 3331 (R. Craig); hillside between Willis run and Coon run, Aug. 10, 1926, 2 ads., N. Y. S. M. No. 3203–3204; Red House valley, Balsam swamp, Aug. 13, 1926, 1 ad., N. Y. S. M. No. 3181; Buffalo Camp, Aug. 21, 1926, larvae; Tunungwant valley, *Limestone,* Aug. 22, 1926, 1 ad., N. Y. S. M. No. 3107. CHENANGO: *Greene,* Aug. 1922, 1 ad., N. Y. S. M. No. 9309 (G. Bartlett); Nov. 8, 1922, 1 ad., N. Y. S. M. No. 9430 (Elmer Bartlett); Apr. 10, 1928, 1 ad.♀ (W. Bartlett); May 4, 1928, 1 ad., N. Y. S. M. No. 4713 (W. Bartlett). CHAUTAUQUA: *Poland Center,* July 8, 1937, 4 yg.; Aug. 31, 1937, 2 juv., Sept. 2, 1937, juv. U. R. No. 4203; Sept. 12, 1937, juv; Oct. 24, 1937, 4 juv. CLINTON: *Plattsburg,* common (G. H. Hudson); *Valcour Island,* 1 ad. (G. H. Hudson). COLUMBIA: *Canaan,* May, 1933, 1 ad. in stomach of 15″ brown trout; *West Lebanon,* July 19, 1922, larvae, N. Y. S. M. No. 1209 (C. Gobler). CORTLAND: *Chicago Bogs,* Oct. 10, 1933, 1 ad.♂ U. R. No. 3258 (W. J. Koster). DELAWARE: *Stamford,* May 13, 1927, 1 ad. (J. Silvernail); Sept. 4, 1927, 1 ad., N. Y. S. M. No. 4114 (Betty Chrisp). ERIE: *Springville,* Sept. 26, 1928, 3♂, 2♀ (F. J. Holl). ESSEX: *Westport,* 2 spec. U. S. N. M. No. 3929 (Cope, 1867, 1889); 1 ad., U. S. N. M. No. 14,494 (F. L. Lee); between *N. Hudson* and *Underwood,* Je.–Sept. 1926 (Weber, 1928); *Mount Pharaoh,* Je. to Sept. 1926 (Weber, 1928); *Paradox lake,* June 23, 1926, 1 ad., 7 egg masses (Weber, 1928). FRANKLIN: Near *Axton,* May 16, 1900, 1 ad. (Evermann, 1918); Apr. 28, 1903 (Evermann, 1918); *Tupper lake,* Sept. 1915, 3 larvae, M. C. Z. No. 1238 (Dunn, 1918). FULTON: *Gloversville,* May 8, 1906, 1 ad., N. Y. S. M. No. 74 (60th Ann. Rep't N. Y. State Mus. 1908). GREENE: (Bishop, 1923); *New Baltimore,* Aug. 1893, 1 ad. HAMILTON: *Raquette lake* (Fowler and Dunn, 1917). JEFFERSON: *Somerville,* 2 ads., M. C. Z. No. 168, 188 (Hough); 3 ads., U. S. N. M. No. 3961 (Cope, 1867, 1889); *Watertown,* May 1881, 1 ad., U. S. N. M. No. 10,575 (J. Q. Adams). KINGS: *Brooklyn, Forest Park,* May 1906 (Engelhardt, 1914); May 10,

1908, 1 juv., A. M. N. H. No. 2630; May, 1909, 1 ad., A. M. N. H. No. 2627 (L. F. Barnum). LIVINGSTON: *Avon,* Sept. 30, 1928, 1 ad. (W. Pierson). MONROE: Common (Wright and Moesel, 1919); *Hamlin Beach Park,* May 21, 1932, eggs; *Mendon Ponds Park,* Apr. 13, 1933, eggs (E. A. Maynard); *Parma,* Apr. 19, 1935, eggs; April 19, 1934, eggs (E. A. Maynard); *Powder Mill Park,* Apr. 11 and 12, 1937, eggs; May 21, 1938, 6 ads., U. R. No. 4450; Mar. 30, 1939, 16 ads.; *Penfield,* May 5, 1931, eggs; Apr. 19, 1935, 1 ad., eggs. NASSAU: *Syosset, Hudson Estate,* Mar. 30, 1927, 1 ad.♀; Mar. 27, 1928, 1 ad.♂. ONEIDA: *Rome,* 1854, 2 ads., M. C. Z. No. 181 (Dunn, 1918). ONONDAGA: *Fayetteville,* May 14, 1928, 2 ads., U. S. N. M. No. 76136–76137 (J. D. Corrington); *Jamesville* (Britcher, 1903); *Onondaga Valley* (Britcher, 1903); *Syracuse, Branchipus pond,* Apr. 12, 1916, spermatophores; Apr. 13, 1916, ads. (J. R. Slater); *Tully* (Britcher, 1903). ONTARIO: *Geneva,* Oct. 2, 1930, 1 ad., Hobart College (T. T. Odell). ORANGE: Near *Highland Falls,* Mar. 2, 1876, 1 ad. on the ice (Mearns, 1898); Oct. 1896, 3 ads. (Mearns, 1898); 2 ads., U. S. N. M. No. 23291–92 (E. A. Mearns); *Kanohwahke lakes,* July–Aug. 1923 (Myers, 1930); *Middletown,* June 19, 1924, 1 ad., N. Y. S. M. No. 1595 (L. D. Greene); *West Point,* 2 ads., M. C. Z. No. 5888–89. OTSEGO: *New Berlin,* Sept. 4, 1935, 2 ads. U. M. No. 78864. PUTNAM: *Garrison,* Oct. 1913, 1 ad., A. M. N. H. No. 3052 (W. Osborn). QUEENS: *Jamaica,* Mar. 24, 1919, 1 ad., A. M. N. H., No. 6403 (H. Boyle). RENSSELAER: common (Bishop, 1923); Oct. 10, 1933, 1 spec., U. R. No. 3256 (W. J. S.); *East Nassau,* Aug. 12, 1927, 6 juv., N. Y. S. M. No. 3941, 3945–49 (S. C. B. and W. J. S.); Aug. 22, 1927, larvae and juv., N. Y. S. M. No. 4090 (S. C. B. and W. J. S.); Apr. 4, 1928, spermatophores and 1 ad. (W. J. S.); Apr. 14, 1928, 4 ads., N. Y. S. M. No. 4743–46; Apr. 30, 1928, 1 ad. (W. J. S.); *Melrose,* Apr. 25, 1926, eggs (H. H. Cleaves); *Rensselaer,* Apr. 13, 1924, eggs and spermatophores (W. J. S.); *Forbes Manor, Rensselaer,* Apr. 2, 1903, 5 batches eggs, N. Y. S. M. No. 70 (F. C. Paulmier); *Stephentown,* Sept. 20, 1922, 1 ad., N. Y. S. M. No. 9311 (R. B. Weston). RICHMOND: *Staten Island* (Davis, 1884); *Snug Harbor,* Apr. 1890 (Davis, 1890); *Gifford,* Apr. 1906, 1 ad. (W. T. Davis); *Inkwell pond,* Apr. 16th, 1915, 1 ad., A. M. N. H. No. 2639 (Skinner, 1916); *Reed's Valley,* 1931, 1 larva (Wilmott, 1933); Apr. 27, 1932, eggs (Davis, 1933). ROCKLAND: *Bear Mountain Interstate Park,* 1923, larvae, A. M. N. H. No. 24223–25; *Sterlington,* Apr. 7, 1928, 2 egg masses (J. A. Weber). ST LAWRENCE: *Brier Hill,* Oct. 16, 17, 1933, 1 ad. (A. Gale, Jr.); *Cranberry lake,* Cat Mountain, June 17, 1915, 1 ad. (P. R. Hough); *Curtis pond,* Aug. 24, 1915, 1 juv., R. S. No. 60; between *Wanakena* and *Dead Creek flow,* June 2, 1931, eggs in trailside pools; *Ogdensburg,* Apr. 20, 1924, 1 ad., N. Y. S. M. No. 1869 (A. Wolf); *Rossie,* 1851 (Hough, 1852). SCHOHARIE: *Gallupville,* Dec. 8, 1922, 1 ad., N. Y. S. M. No. 9446 (E. G. Hay). STEUBEN: 1¾ mi. s.w. *Addison,* July 1, 1937, U. R. No. 4130 (Raney). SUFFOLK: *Cold Spring Harbor,* Aug. 1900 (Engelhardt, 1914); Spring 1927 (Breder, 1927); 1927, C. M. No. 4154 (R. Boulton); *Cutchoque,* Sept. 14, 1923, 1 ad. (R. Latham); *East Marion,* Sept. 26, 1931, 1 ad. (R. Latham); *Greenport,* Nov. 4, 1931, 1 ad. (R. Latham); *Huntington,* Aug. 1913 (Engelhardt, 1914); *Mattituck,* Apr. 20, 1923, 3 spec. (Roy Latham); *Miller Place,* May 31, 1915 (F. Harper); *Jones' pond, Miller Place,* June 23, 1928, many larvae (S. C. B. and J. A. W.); *Montauk,* Nov. 13, 1925, 1 ad. (E. P. Latham); *Orient,* Sept. 30, 1932, 1 juv. (R. Latham); *Shelter Island,* Aug. 7, 1930, 1 juv. (R. Latham); *Southold,* Sept. 25, 1915, 1 ad. (Roy Latham). SULLIVAN: 1 ad (W. T. Davis). TOMPKINS: *Bool's backwater,* Ithaca, Apr. 5, 1912, spermatophores, C. U.; Apr. 12, 1912, ad.♀ C. U.; Apr. 5, 1923, ads., C. U.; *Bethel grove,* May 7, 1931, larvae (Hamilton); Mar. 29, 1935, eggs (Hamilton); *Coy's glen,* Apr. 1, 1917, 1 ad., C. U.; *Enfield falls,* Apr. 11, 1914, 3 ads., spermatophores (F. Harper); *Fall creek,* Apr. 21, 1924, 1 ad. eggs (F. Harper); *Forest Home,* Mar. 30, 1907, 1♀, C. U.; Apr. 15, 1909, eggs, C. U.; Mar. 1910, C. U.; Mar. 27, 1920, C. U.; Mar. 27, 1922, C. U.; *Ithaca,* June 4, 1883, C. U.; Mar. 28, 1884, C. U.; (Gage and Norris, 1891); June 1904, larvae, M. C. Z. No. 4346–50 (R. V. Chamberlin); Oct. 8, 1907, C. U.; Mar. 1908, C. U.; Mar. 29, 1910,

C. U.; Apr. 1915, C. U.; Apr. 17, 1917, 1 ad. (J. D. Corrington); Mar. 10, 1921, C. U.; (Dunn, 1918); Mar. 24, 1929, eggs (Hamilton); Apr. 14, 1929 (Hamilton); Apr. 8, 1932, eggs (Hamilton); *McLean bogs,* 1922–1925, ad. and eggs (Leffingwell, 1926); May 2, 1934, 3 ads., U. R. No. 3412; *Pleasant Grove creek,* Mar. 31, 1924 (E. L. Palmer); *Renwick* (Ithaca) Mar. 29, 1908, 2 ads., U. S. N. M. No. 29402–03 (Wright and Allen); Mar. 20, 1913, spermatophores, C. U.; Apr. 9, 1915, ads., C. U.; Apr. 4, 1919, eggs, C. U.; Apr. 14, 1924, eggs (F. Harper); Apr. 13, 1925, ads. and eggs (F. Harper); May 8, 1929, eggs (Hamilton); *Ringwood,* July 30, 1931, larvae (Hamilton); *Slaterville,* June 30, 1927, 1 ad., U. R. No. 1202 (P. R. Needham); *Snyder hill,* Apr. 19, 1914 (F. Harper); *Tarbel,* June 1, 1915, 1 ad. (W. T. Davis); *Taughannock creek,* Oct. 1, 1922, C. U. WASHINGTON: (Eights, 1835); *Cossayuna lake,* Aug. 28, 1927, 1 juv. (J. Heller). WAYNE: *Lake Bluff,* Sept. 9, 1920, 1 ad., N. Y. S. M. No. 9115; *Blind Sodus bay,* Apr. 23, 1933, 1♂, 4♀; common in Wayne (Wright and Moesel, 1919). WESTCHESTER: (Fowler and Dunn, 1917); (Deckert, 1914).

Records too indefinite to be included under counties: *New York* (Boulenger, 1882); Generally distributed over the State (Eckel and Paulmier, 1902); "Sparing in damp woods in vicinity of *New York*" (Ditmars, 1905); *Catskill Mts.,* 1880–82 (Bicknell, 1882); Common throughout the *Cayuga Lake basin* (Reed and Wright, 1909); *Cayuga lake,* U. S. N. M. No. 17931–38; *Seneca lake,* 1899, U. S. N. M. No. 36007; *Lake Champlain,* May 23, 1921, 1 ad., A. M. N. H. No. 8096 (G. C. Fisher); *Pell's pond, Hudson Highlands,* Apr. 8, 1883 (Mearns, 1898); the following from *Long Island,* collected by Nicholas Pike, are in the collections of the American Museum of Natural History: 1880, larvae and juv., No. 2447; July 1884, 1 ad., No. 2640; 9 ads., No. 2641, 2611–12; 2614–20; 2622–24; larvae and juv., No. 4456–64; juv. 1886, No. 2633–7; ads. and larvae, 1887, No. 2613; larvae and juv., 1887, No. 2465–75.

Condensed Bibliography

Life history and habits. Andrews, 1897, p. 635–37 (*Amblystoma punctatum*); Bishop, 1927, p. 42–45 (*Ambystoma maculatum*); Blanchard, 1930, p. 154–67; Breder, 1927, p. 51–56; Brimley, 1921, p. 26–27; Clarke, 1880, p. 105–25 (*Amblystoma punctatum*); Cochran, 1930, p. 185 (*Ambystoma maculatum*); Dempster, 1930, p. 182–92; Eycleshymer, 1895, p. 343–418 (*Amblystoma punctatum*); Gadow, 1923, p. 110–11; Hay, 1889, p. 602–12; Mohr, 1930, p. 50–55 (*Ambystoma maculatum*); Orr, 1889, p. 295–324 (*Amblystoma*); Piersol, 1929, p. 57–74 (*Ambystoma maculatum*); Pope, 1919, p. 66; Pope, 1928, p. 99; Smallwood, 1928, p. 90 (*Amblystoma maculatum*); Smith, 1907, p. 381–90 (*Amblystoma punctatum*); Smith, 1910, p. 204–11 (*Ambystoma punctatum*); Smith, 1911, p. 14–27; L. Smith, 1921, p. 41 (*Ambystoma maculatum*); Surface, 1913, p. 87 (*Amblystoma punctatum*); Wright, 1908, p. 284–89; Wright and Allen, 1909, p. 687–92.

Distribution in New York. Bicknell, 1882, p. 124 (*Amblystoma punctatum*); Bishop, 1923, p. 65 (*Ambystoma maculatum*); Bishop, 1927, p. 42–45; Boulenger, 1882, p. 41 (*Amblystoma punctatum*); Breder, 1927, p. 51–56 (*Ambystoma maculatum*); Britcher, 1903, p. 120 (*Amblystoma punctatum*); Cope, 1867, p. 177; Cope, 1889, p. 56–61; Corrington, 1931, p. 77 (*Ambystoma maculatum*); Davis, 1884, p. 13 (*Amblystoma punctatum*); DeKay, 1842, p. 74 (*Salamandra subviolacea*); Deckert, 1914 (*Amblystoma punctatum*); Ditmars, 1905, p. 166; Dunn, 1918, p. 457 (*Ambystoma maculatum*); Eckel and Paulmier, 1902, p. 399 (*Amblystoma punctatum*); Eights, 1835, p. 6 (*Salamandra subviolacea*); Engelhardt, 1914 (*Amblystoma punctatum*); Evermann, 1918, p. 50 (*Ambystoma maculatum*); Fowler and Dunn, 1917, p. 9 (*Ambystoma punctatum*); Gage and Norris, 1891, p. 339 (*Amblystoma punctatum*); Green, 1827, p. 7 (*Salamandra subviolacea*); Hough, 1852, p. 24; Leffingwell, 1926, p. 72 (*Ambystoma maculatum*); Mearns, 1898, p. 323 (*Ambystoma punctatum*); Myers, 1930, p. 100 (*Ambystoma maculatum*); Reed and Wright, 1909, p. 402 (*Ambystoma punctatum*); Sherwood,

1895, p. 26; Skinner, 1916, p. 98 (*Amblystoma punctata*); Smith, 1907, p. 284 (*Amblystoma punctatum*); Smith, 1910, p. 204–11 (*Ambystoma punctatum*); Smith, 1911, p. 14–27; Weber, 1928, p. 106 (*Ambystoma maculatum*); Wilmott, 1933, p. 161; Wright, 1908, p. 284–89 (*Amblystoma punctatum*); Wright and Allen, 1909, p. 687; Wright and Moesel, 1919, p. 63 (*Ambystoma maculatum*); Yarrow, 1883, p. 147 (*Amblystoma punctatum*); 5th Ann. Rep't State Cab. Nat. Hist., 1852, p. 24 (*Salamandra subviolacea*); 60th Ann. Rep't N. Y. State Mus. 1908, p. 99 (*Amblystoma punctatum*); Proc. Nat. Sci. Ass'n Staten Island, 1890, p. 47 (*Amblystoma punctata*).

General. Stejneger and Barbour, 1923, p. 5; Stejneger, 1902, p. 239–40 (*Ambystoma maculatum*); DeKay, 1842, p. 74 (*Salamandra subviolacea*); Holbrook, 1842, p. 67–69 (*Salamandra venenosa*); Cope, 1889, p. 56–61 (*Amblystoma punctatum*); Kingsbury, 1895, p. 261–98; Storer, 1925, p. 83; Guide to Nature, p. 190 (*Amblystoma maculatum*).

AMBYSTOMA OPACUM (Gravenhorst)

(*Salamandra opaca,* Vergl. Uebers. Zool. Syst., 1807, p. 431)

Marbled Salamander, Banded Salamander

Figures *2d, 4f,* 28–29, *33d–e*

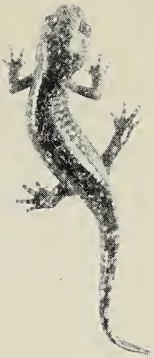
The marbled salamander is the smallest species of *Ambystoma* found in the State and the most strikingly marked. It is fairly common in several localities but is near the northern limits of its range and localized in areas of southeastern New York.

Description

Size. The average length of twenty adults of both sexes is 99.1 mm (3 15/16 in.), with extremes of 85 and 120 mm. The females in the series measured average slightly longer than the males, 99.4 mm. In these the tail comprises from 36.4 to 41.7 per cent of the total length. Ten males average 96.7 mm in total length with extremes of 85 and 112 mm. In the males there is greater variation in the length of the tail which may comprise from 34.8 to 42.3 per cent of the total.

Uhlenhuth (1921, p. 351) gives some interesting information on the size attained by *A. opacum* at different ages and maximum size attained under natural conditions. The largest animal on record in his laboratory at the time his paper appeared was 115 mm long at the age of 79 weeks. The largest among fifteen specimens from two to three years old measured 113.5 mm, the average, 103.5 mm. Two breeding females measured shortly after being taken were 112 and 106 mm respectively. The largest found in the collection of the American Museum of Natural History was 117.7 mm; the average of the eight largest, 100.3 mm. In the U. S. National Museum collection, the largest specimens measured 119 and 116 mm. As noted above, my largest specimen was a female measuring 120 mm.

a



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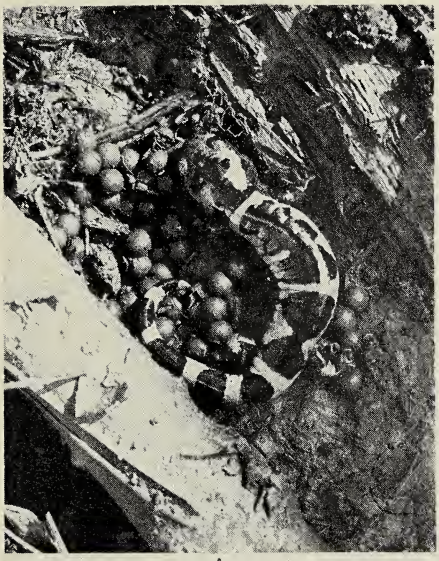


d

e

Fig. 28 a. *Ambystoma opacum*, mature male from Raleigh, N. C., Oct. 26, 1923. b. Recently transformed juvenile, Jones pond, Miller Place, Long Island, N. Y., June 23, 1928. Actual length 60 mm. c. Transforming larva, actual length 68 mm. Coram, N. Y., June 23, 1928. d. Female guarding eggs, Raleigh, N. C., October 26, 1923. e. Mature male, Jones pond, L. I., Sept. 3, 1922.

Form. The body is thick, short, and more or less cylindrical or slightly depressed. The skin is generally very smooth and shiny without any evidence of a dorsal groove in well-fed and developed specimens. The head is moderately broad, slightly rounded above and widest a short distance behind the eyes at a point above the angle of the jaw. The gular fold is prominent and continued high on the sides and from it arises a short longitudinal groove running to the eye. From the angle of the jaw a vertical groove joins the horizontal groove just back of the eye. The eyes are moderately large and prominent with pupil and iris black or very dark brown. There are 11 costal grooves in the majority of specimens or 12 if the count includes a groove running to a point above the insertion of the foreleg. Ordinarily the axillary groove is lacking. The legs are moderately long and stout with five toes on the hind feet, the toes in order of length 1-5-2-3-4, the last named the longest. On the front feet the order is 1-4-2-3. Palmar tubercles two, well developed; plantar tubercles two, small.

While the glands of the skin are numerous and generally distributed they are not conspicuously developed on the head and only slightly enlarged on the dorsum of the tail. The tail is fleshy, subelliptical in cross section, without a keel, and thicker above than below. Laterally it is marked by impressed vertical lines variable in number.

The tongue is broad, thick and fleshy with the plicae radiating from a V-shaped area in the back to the margin. The teeth are in a transverse sinuous line which is quite widely interrupted back of the inner nares and rarely narrowly interrupted at the middle of the central series. Sometimes the teeth of the central series are in a fairly straight line but in most they form a double arc, convex behind.

Color. The ground color is deep lustrous black with brownish tinges on the under side of the head and on the legs and toes. The light markings, which are bright white in the males, especially during the breeding season, and dull grayish in the females, are extremely variable in size, shape and distribution. In general they are restricted to the back and upper sides of the head, trunk and tail and are arranged in transverse bands, narrowed dorsally and widened on the upper sides where they frequently unite with the ends of adjacent bands to inclose a series of fairly regular black spots along the midline of the back. Sometimes the dorsal light bands are in the form of transverse X-shaped marks and the ends of the bifurcations may or may not unite with their fellows before

and behind them. Frequently the light markings of the back fuse along each side to form fairly regular longitudinal bands on the trunk; a more common arrangement is the presence of a single, broad, median light band which incloses a series of dark figures which may or may not be connected. A pattern less frequently observed is one in which the light markings of the trunk are limited to narrow cross bars slightly widened at the ends. Both sexes may exhibit all the varying types of color pattern.

On the tail the light markings usually form simple transverse bands which, when viewed from above, give the tail the appearance of being ringed. On the head, in many specimens, there is a black central figure of irregular size and shape, partially or wholly surrounded by white; and usually the snout is black tipped. The belly may be uniformly bluish black, brownish black or with small scattered light flecks on a dark ground.

Sexual differences. As noted above the light markings of the male are bright white, the contrast between this color and the grayish white of the female being particularly noticeable during the breeding season. In the females there is a greater tendency toward the development of brownish tinges on the legs and toes. The vent of the female is a simple slit and is slightly protuberant only in the breeding season. The vent of the male, on the other hand, is somewhat protuberant at all seasons and strongly protuberant and swollen during the mating season and well into winter.

Activities of the Breeding Season

Migration. There is a definite migration of the adults to the breeding grounds in the fall (in the northern parts of its range usually in September) and the males ordinarily precede the females by a few days as in some other species of *Ambystoma*. In the summer, the dispersal of the recently transformed young from the waters in which they developed is, in some years, such a concerted movement that it takes on the character of a migration; in other years, however, the period during which transformation takes place is an extended one and the salamanders leave the ponds a few at a time. Much depends on the season. When the ponds begin to dry early, transformation is forced and all individuals that have attained sufficient growth and development may leave at approximately the same time.

Mating. In striking contrast to the habits of the majority of the species of *Ambystoma,* which deposit their eggs early in the

spring in water, the marbled salamander deposits its eggs in the fall on land. The eggs, however, are deposited in situations which will insure their being submerged with the rise of water accompanying fall and winter rains and consequently the salamanders congregate near the margins of ponds, streams and swamps for the egg-laying season.

Except during the egg-laying season this salamander is widely distributed and likely to be found under bark, logs or stones some distance from water in fairly dry and shady situations. In September this species is to be found hiding beneath the matted rubbish in the beds of dry ponds or swamps, under old logs and boards, beneath stones lying in the beds of dry ponds, along the margins of shrunken water courses or just above the water line of ponds that later will be filled by rains. Noble and Brady (1933, p. 93) record the discovery of nests beneath the sphagnum mat covering the roots of fallen trees; on moist banks in the depressions made by the hoofs of cows; and at the sides of mouse tunnels about three inches below the surface of the sandy bottom of a dry pond.

It has been mentioned above that the males usually precede the females to the breeding grounds. After the arrival of the females, both sexes may be found beneath the same retreat and often a considerable number will congregate in a limited area and make use of every available shelter.

Observations of Lantz (1930, p. 322) and of Noble and Brady (1933, p. 98) have indicated that the marbled salamander, as in other species of *Ambystoma,* indulge in a kind of courtship preceding the deposition of spermatophores. This courtship is apparently initiated by the males. At its inception, the males were observed to butt and attempt to force their snouts under other individuals of either sex they happened to encounter. Males were frequently pursued by other males, the process serving to stimulate all concerned. If the butted individual attempted to escape, the courting male frequently threw his hind legs and tail across the line of retreat. Sometimes the efforts of the male seemed to be directed toward thrusting his snout under the cloaca of the female, and the female responded by like thrusts in the region of the cloaca of the male. These efforts, when carried on simultaneously, resulted in a circular movement of the pair which Noble and Brady designated as the "waltz."

Spermatophores. The first definite evidence of the production of spermatophores by the males of this species was found in October 1929 when a specimen collected by Henry Dietrich at Merrill, Miss., was forwarded to me at Rochester, N. Y., and found on examination

to be a female carrying a well-formed spermatophore in the posterior end of the vent. The specimen was collected October 7th and was several days in transit but the spermatophore retained the terminal cap and a portion of the gelatinous base.

Lantz (1930, p. 323), studying the behavior of captive specimens, found and described the first complete spermatophores. The spermatophore is well figured by Noble and Brady (1933, p. 103) who described it as follows:

> It measures 4 to 5.5 mm in height and its stalk is approximately 2 mm wide at the apex and 6 mm wide at base. It differs from the spermatophore of *Ambystoma maculatum* in being smaller and in having a quadrangular or pentangular summit. Each corner of the summit is formed by a low rounded prominence and the top of the structure is truncate and slightly concave. In the fresh spermatophore these summits are usually covered with a mass of sperm which are thus placed in a decidedly advantageous position for being engulfed by the cloaca of the female. (Figure after Noble and Brady)

Following the courtship, although not always at the climax of the activities, the male produces a spermatophore. The female is frequently nosed by a male who passes his snout along the side of the female's body until the tail is reached. Preceding the actual production of a spermatophore, the male undulates the base of the tail and at the instant of production the body of the male is raised on stiff legs and the spermatophore extruded. After deposition the male was observed to again nose the female. Sometimes the female followed the male immediately, passing her chin and body over the spermatophore until her cloacal region came in contact with it; here she either remained motionless for a few seconds or undulated her pelvic region. At other times she nosed about for several seconds before discovering the spermatophore with her snout and covering it with her cloaca.

The nest of the marbled salamander. The nests are usually little depressions or cavities in the ground beneath some sheltering object. I have found them beneath the drift debris along the margins of woodland streams, beneath a layer of moss at the margin of a woodland pond and under logs, bark and pieces of board in the beds of dry ponds. They are reported from beneath stones and Brimley (1920, p. 25) found the eggs between two thick pieces of pine bark which were buried beneath rubbish near the margin of a stream. In the great majority of cases, the eggs are found in contact with the soil and from the shape of the cavity they occupy, it is evident the female turns herself around a number of times in forming it.

At Oakwood, Va., Brady found great numbers of brooding females beneath the leaf mold on dry pond bottoms. When the mat of leaf mold was rolled back a ramification of tunnels was exposed in which the brooding females lay with their eggs. They occupied shallow depressions at various points along the tunnels and here, as elsewhere, there was some evidence that the activities of the female had had a part in shaping the retreat.

In all instances where eggs have been found in the field, the female accompanied them. She curls about or upon them, in contact with a considerable number at first, but as the eggs become scattered by her movements only a comparatively few are against her body. Under usual field conditions, the eggs in contact with the body are considerably larger than those away from her. This is particularly noticeable during a dry season and it is evident that the brooding habit, in addition to the protection afforded against enemies, provides against too much drying. Females under observation in the laboratory were found to shift their positions at intervals and while these movements scattered the eggs they also brought the body into contact with different eggs at different times.

The eggs are able to withstand considerable desiccation and may shrink to one-third the normal size without injury.

The egg mass. Unlike the other species of *Ambystoma* in the State, the marbled salamander deposits the eggs singly. While forming a more or less compact group they are not aggregated by a common envelop. Under normal field conditions they are only slightly adhesive but when partly dried as many as six or eight may be picked up together. When placed in water they lose their adhesiveness. The actual color in the field is usually obscured by the silt and bits of rubbish that cling to the outer envelop, the surface of which is clear, sometimes slightly wrinkled and sticky when dry.

The egg-laying season. The egg-laying period is limited to the fall and early winter months, the time depending somewhat on the character of the season and the latitude. Mann (1855, p. 294) mentions eggs taken in November and December at Gloucester Court House, Va. According to Brimley (1896, p. 500) the eggs are laid in October and November in the vicinity of Raleigh, N. C., and it was here in 1923 that two females with eggs were found on October 26th (Bishop, 1924, p. 88). Deckert (1916, p. 23) found eggs with an adult on September 25, 1913 at Silver lake near White Plains, N. Y. Some females taken by Dunn (1917, p. 42) September 20th, 1916 at Mount Vernon, Va., deposited eggs in the con-

tainer September 21st. Eggs taken at Syosset, N. Y., October 1918 are in the collections of the American Museum, New York, and Noble and Brady (1933, p. 90) give additional Long Island and other records as follows: at Hartsdale, N. Y., a female with eggs which were laid between October 2 and 4, 1931, was observed by G. P. Engelhardt; females from Long Island taken to the laboratories of the American Museum deposited eggs as late as September 28, 1931; a Washington, D. C. specimen, taken to England and reported on by Lantz (1930, p. 322), deposited eggs two successive years during the first half of October; J. A. Weber found six females with eggs at Greensburg, La., October 25, 1930; a female with eggs was found September 18, 1931, near Coram, Long Island; on September 19, 1931, at Jones' Pond, Miller Place, Long Island, 12 females with eggs; near Melville, Long Island, September 21, 1931, many females with eggs. Eggs collected in the Washington area by Brady were well advanced October 3–6, 1929.

In general it may be said that the egg-laying season in New York may start as early as September 18th on Long Island or as late as the first week in October in Westchester county.

The number of eggs deposited by a single female varies from 50 to more than 150, according to McAtee (1907, p. 13). Mann (1855, p. 294) records a batch taken in December which contained 108 eggs. On October 26, 1923, while collecting with C. S. Brimley in the Walnut creek bottoms near Raleigh, N. C., six adults were found including two females with eggs. These females were discovered under masses of rotten wood and debris left by flood waters of the creek. The eggs in the two nests numbered 102 and 73 respectively, all with well-developed embryos. The two lots of eggs secured by Lantz from a female in captivity numbered 94 and 103 (Lantz, 1930, p. 322). Noble and Brady (1933, p. 110) give the following figures for fifteen sets taken at Oakwood, Va.: 75, 81, 101, 122, 125, 132, 139, 143, 147, 167, 173, 191, 193, 226, 232, or an average of about 150. King (1935, p. 13) found the average number of eggs in 25 nests to be 98.

In the field the female may remain with her eggs until the nest site is flooded, a period sometimes extending a month or two, or she may desert them after a few weeks. In dry seasons the tendency is to remain with the eggs longer than during periods when the nest site retains considerable moisture.

Development

The egg and its envelops. In addition to the vitelline membrane, the individual egg has two definite envelops, the outer sepa-

rated from the inner by a layer of viscid jelly. Within the inner envelop, the embryo apparently floats in a thin, clear fluid that is perfectly transparent and only slightly viscid. The outer envelop is tough and elastic, the inner one thin, clear, and even more elastic.

Noble and Brady (1933, p. 111) prefer to regard the jelly layer as a definite capsule because in formalin it becomes somewhat hardened and may be removed almost entire. In the fresh egg, however, it is thin and will flow as a clear jelly from a pricked egg. Noble and Brady also recognize a thin outer capsule in addition to those mentioned above. It is true that the outer surface of the egg is more adhesive than the material just beneath, but in my specimens, both fresh and preserved in formalin, I have been unable to make out a definite layer. Many amphibian eggs if preserved and sectioned will exhibit the capsules as laminated structures but these minor layers can not be regarded as separate envelops.

The size of the egg with its envelops varies according to the amount of moisture present in the environment. The average diameter of 30 taken from a nest cavity in the earth and rotten wood, was 4.76 mm, but individuals varied from 4 to 5.2 mm. When the diameter of the outer envelop is 5 mm, that of the inner one is approximately 4 mm. The egg itself is 2.7 mm in diameter, dull yellow and without pigment.

The measurements given above agree essentially with those obtained by Lantz (1930, p. 323) who indicated a diameter of 4 to 5 mm for the envelops and 2.5 mm for the vitelline sphere. Noble and Brady (1933, p. 111) give the following measurements: diameter of the egg, 2.8 mm, outside diameter 5 mm.

The incubation period. The length of the incubation period varies from season to season and depends, apparently, on the amount of moisture present and to a less extent on temperature. While it has been shown by Noble and Brady (1933, p. 120) that under laboratory conditions all eggs do not need to be entirely covered by water to insure hatching, only 13.39 per cent of nearly 300 eggs used in their experiment hatched when the eggs were kept in covered glass containers on saturated sand. On the other hand, when the eggs were immersed, 86.75 per cent of 296 eggs used in the experiments hatched, the majority of them within a few days. Under natural conditions nest sites are almost invariably selected that will insure complete immersion of the eggs and since the newly hatched larvae are incapable of traveling any distance over the earth, whether or not it is saturated, there is little likelihood that many eggs hatch in the field in the absence of sufficient water to

cover them. The experiment of keeping eggs in a covered dish on saturated sand has no counterpart in nature and proves only that a few eggs may hatch under these unnatural conditions; it does not disprove the general contention made by Dunn (1917) and others that under natural conditions in the field the young survive only when covered by water.

The minimum length of the incubation period for this species is approximately 15 days (King, 1935, p. 13) and it is well known that the period may be greatly extended by keeping the eggs only slightly moist. Brimley (1920, p. 25) found a female with eggs October 3, 1919, and 52 days later, November 24th, the embryos were still within the envelops but ready to hatch. Some eggs with well-advanced embryos which I collected October 26, 1923, were retained 41 days in moist earth and rotten wood, or until December 6, 1923, when they were covered by water and hatched within 24 hours. Lantz (1930, p. 324) kept one egg on land for a period of 207 days. A second egg placed in water the day after it was laid remained alive four days longer than the other. Noble and Brady (1930*a*, p. 274) kept eggs collected October 4th on damp sand at room temperature and they remained viable until March 4th, a period of 151 days. The longest period eggs have been kept alive is recorded by Noble and Brady (1933, p. 122) as extending over a year. Eggs were kept in an ice box at temperatures of 7° to 10° C., and while they did not hatch, the inclosed larvae were alive at the end of the experiment.

Under normal conditions in the field, the majority of the eggs of this species doubtless hatch in the fall or early winter months. Occasionally, during a dry season, the nest sites are not flooded and the eggs remain through the winter. In the Washington area, Brady found several small lots of eggs during March 1931. The embryos were in an advanced stage of development and the majority of them escaped the envelops when placed in water or on wet blotting paper.

The newly hatched larva. In hatching the embryo breaks through the envelops leaving a ragged or, in some cases, a crescentic opening with the inner envelop protruding. The separate envelops often retain their relative positions after the larvae have escaped and the inner thin envelop and its surrounding layer of clear viscid jelly may be removed from the stronger outer cover. The larvae may escape either tail or head first and remain clinging to the envelops only a short time. Noble (Noble and Brady, 1933, p. 125) objects to the use of the expression, "the embryo breaks

out of the capsules" but this is exactly what happens in many cases. The so-called "hatching glands" on the head of the embryo may soften the envelops so that they are easily ruptured but it is usually the contortions of the active embryo within that cause the final break.

The degree of development and length of the larvae at hatching depend on how long they are forced to remain in the egg. Normally the larvae attain a length of about 19 mm. Fourteen larvae at hatching averaged 18.35 mm with extremes of 15 and 19 mm. This is in substantial agreement with the measurements obtained by Brimley (1920, p. 25) who mentions 19 mm as the length of larvae hatched at Raleigh, N. C., in November. The length at hatching of some larvae from eggs taken by Deckert (1916, p. 23) at White Plains, N. Y., and hatched September 28, 1913, is given at five-eighths of an inch or 16 mm. According to McAtee (1907, p. 13) the embryos may reach a length of one inch before release, if hatching is delayed. Lantz (1930) gives 15–19.5 mm as the length at which his specimens hatched. Noble and Brady (1933, p. 118) give a much greater range of hatching lengths, from 10.5 to more than 20 mm, when eggs were brought from the field and placed in water. Their specimens ranged from, "very early larval stages in which the eyes were not yet functional, the lips barely formed, the gills without rami, and the fore limb in a rudimentary bud stage, to advanced stages in which the balancers had entirely disappeared, the four digits of the fore limb had become differentiated, the rear limb bud had appeared and the larva had assumed a mature larval habitus."

Eggs apparently at the point of hatching in the field were brought into the laboratory and placed in water. In 24 hours all had hatched and exhibited the color and structural features here indicated. The larva is uniformly lightly pigmented and has a grayish tinge but the general color rapidly darkens after exposure to the light and becomes more brownish. Immediately after hatching it is marked above with minute black pigment flecks on the head and back and a few small rounded or oval areas, free from pigment, on each side of the middorsal line. The tail fins and sides are mottled with yellowish areas where pigment is lacking, the spots most numerous on the sides back of the gills and fore limbs. In some individuals there is a fairly regular arrangement of light spots to form a lateral band. The black pigment is concentrated on the head in a triangular patch which sends a narrow extension backward toward the dorsal keel.

The gills and their filaments are long, slender and tinged with gray and yellow. The fore legs are slender and delicate but with the toes well developed, the fourth shortest, about half as long as the first. The hind legs are represented by elongate buds without indication of toes. In these specimens, the balancers were lost before hatching but often they are retained for several days after the escape from the envelops.

Compared with the other species of *Ambystoma* found in the State, the larvae of *A. opacum* at hatching are ordinarily more advanced, especially in the development of the fore limbs, and the reduction or loss of the balancers. From the recently hatched larva of *A. jeffersonianum,* the larva of *A. opacum* differs conspicuously in its color, in the lack of the paired dark spots developed along each side of the dorsal fin, in the greater development of the limbs, particularly the fore, and in the early loss of the balancers; from the larva of *A. maculatum* it differs in general color, in the lack of conspicuous dark pigment spots on the back and upper sides, in the greater development of the limbs and in the earlier loss of the balancers; from the larva of *A. tigrinum,* that of *A. opacum* differs in its usually larger size at hatching, in its general color, in the lack of definite alternating dark and light areas on each side of the middorsal line, in the more uniform distribution of pigment on the sides of the trunk and tail fins, and in the development of balancers. In *A. tigrinum,* the balancers are only rarely developed, the tail fins are only slightly pigmented and the sides of the trunk are rather strongly mottled. My specimens of *A. tigrinum* at hatching lacked the limb buds.

Larval development. Under usual conditions in the North, the eggs hatch in the fall or early winter and the larvae remain in the water without much growth through the colder months. On Long Island, N. Y., near Syosset, Engelhardt (1916, p. 88) found larvae 29 to 32 mm long on April 7th. Collecting with Jay A. Weber in a roadside pond at Coram, N. Y., March 28, 1928, we took larvae with total lengths as follows:

23 mm	33 mm	35 mm
27 mm	34 mm	35.5 mm
28 mm	34 mm	36 mm
32 mm	34 mm	37 mm
33 mm	34 mm	40 mm
33 mm	35 mm	43.5 mm

The average length of these 18 specimens is 33.7 mm.

At Syosset, N. Y., on March 27, 1928, a single larva among others taken, had attained a length of 45 mm. These figures probably represent the extremes attained by larvae hatched in the fall or

early winter months in the latitude of Long Island. The proportions of a typical specimen are: length, 40 mm; head length, 9 mm; head width 7.5 mm; tail 15 mm. The head is noticeably broad and flat and the snout very blunt. In general the specimens are very dark in color although an occasional individual will have tinges of greenish yellow or gray. The color pattern is essentially as follows: the head is very heavily pigmented with black and dark brown over a dull orange ground color. There is a darker central area marking the position of the brain, a dark patch over each eye and a broad dark bar from each eye to the nostril of the same side. The gills are heavily fringed, strongly mottled with dull orange and black, and broadly flattened above. The fore legs are very well developed and mottled with black and yellow; the toes in order of length from the shortest, 4-1-2-3. The hind legs are very imperfectly developed, short, and in the smaller specimens, directed backwards along the sides. The trunk above is generally dark with just an indication of pale spots arranged in pairs, one on either side of the dorsal keel. The sides of the trunk are rather uniformly pigmented and marked with a series of pale spots which may be faint and limited to the region just above the hind legs or continued forward as a well-defined series to the fore legs. The lower sides are mottled and the tail keels more strongly blotched with black and yellow chromatophores. Large pale yellow spots are developed along the upper tail fin, in a broken series just above the midline of the tail and again on the lower margin of the lower tail fin. The throat is dull whitish with small scattered black chromatophores and the belly grayish white.

The size attained by larvae at different New York localities during the spring months is indicated below, all measurements given in millimeters. A few figures for specimens taken in other localities are appended for comparison.

LOCALITY	DATE	TOTAL LENGTH	REFERENCE
White Plains, N. Y...	Apr. 1915.....	about 50 mm..	Deckert, 1916, p. 23
Syosset, N. Y.....	late May 1915.	63 mm.....	Engelhardt, 1916, p. 89
Syosset, N. Y.....	Apr. 7, 1916..	28–31.5 mm....	Engelhardt, 1916, p. 88
E. Norwich, N. Y....	Apr. 20, 1916..	31.5 mm.....	Engelhardt, 1916, p. 89
Coram, N. Y.....	Apr. 30, 1916..	25 mm.....	Engelhardt, 1916, p. 89
Coram, N. Y.....	Mar. 28, 1928..	23–43.5 mm....	S. C. Bishop and J. A. Weber, coll.
Coram, N. Y.....	June 23, 1928..	full grown.....	S. C. Bishop and
		69–70 mm.....	J. A. Weber, coll.
Syosset, N. Y.....	Mar. 27, 1928..	(1) 45 mm....	S. C. Bishop and J. A. Weber, coll.
Fort Lee, N. J.....	Apr. 17.....	12.5–31.5 mm..	Sherwood, 1895, p. 27
Lakewood, N. J.....	June 1912.....	25–38 mm.....	Engelhardt, 1914
Raleigh, N. C.....	Apr. 2, 1915..	37–43 mm.....	C. S. Brimley, coll.
Florence, Mass.....	Apr. 15, 1918..	26.5 mm.....	Dunn, 1919, p. 51

I am suspicious of the Fort Lee records of Sherwood, especially the ½ inch (12.5 mm) larvae taken April 17th. The April records of all other observers indicate a larval length varying from 25 to 50 mm. The specimens recorded by Engelhardt, from Lakewood, N. J., in June, are also remarkably small for the species at this period of the year.

Length of the larval period. The length of the larval period in any locality varies from year to year. This is obvious when account is taken of the fact that rains must insure the flooding of the nest sites. Temperature also plays an important role. The young larvae feed actively when the waters are moderately warm; they are relatively inactive during the cold periods in the north. With early fall rains the larvae hatch and attain considerable size during the late fall months; with late rains and colder temperatures, growth is almost negligible.

In general, it may be said that the marbled salamander in the latitude of Long Island, N. Y., transforms in June. If the eggs have hatched during September or October preceding, the larval period will have extended eight or nine months. Lantz (1930, p. 323) found the larval period extending 130 to 166 days under laboratory conditions but this can hardly represent the normal development.

In some years transformation takes place in May and Sherwood (1895, p. 27) found that many had deserted the ponds as early as May 8th. Deckert (1916, p. 23) found that larvae which were two inches long in April, transformed in early June.

On Long Island, N. Y., transforming young were taken June 23, 1928, at Jones' pond, Miller Place and at Coram. In 1929, J. A. Weber secured metamorphosing larvae at Miller Place, July 4th.

Mature larvae. Full grown larvae taken June 23, 1928, at Coram, N. Y., varied in length from 63 to 74 mm. In these the ground color shades from light olive and deep brown to almost black. Light spots are present on the head, where they are numerous and very small, and on the back where they are fewer, larger, paler, and rarely arranged in pairs one on either side of the midline. There are large, light yellowish or greenish blotches on the tail which give a somewhat banded appearance. The upper sides are marked by a fairly regular row of pale spots and between the legs, at a lower level, there is a broken line of small pale spots.

As the larvae approach transformation, the keels of the tail are lost before the gills are greatly reduced.

In the mature larvae the head is broad and with the sides back of the eyes nearly parallel or slightly diverging posteriorly. The snout is somewhat truncated. The dorsal tail keel extends forward to a point well in advance of the midlength of the trunk. The legs are slender but well formed, the hind legs longer and heavier than the fore though, until a length of approximately 40–45 mm is attained, they are very much shorter.

Transformation. Among a lot of mature larvae taken at Coram, N. Y., June 23, 1928, were 31 specimens transforming at an average length of 71.5 mm. The extremes were 63 and 75 mm long. These individuals were seined from a fairly deep and well-shaded pond in the pine barrens. In a shallower pond in the open, where, earlier in the season, the larvae had been extremely abundant transformation had apparently already taken place. It would seem, therefore, that the character of the water, its temperature as modified by depth and shade, and perhaps the amount of food available, influences the development of larvae and hastens or retards growth and transformation.

On the date specimens were collected in water at Coram, June 23d, six recently transformed specimens were collected from beneath old planks on a hillside above Jones' pond at Miller Place. These specimens averaged about 66 mm in length. Wilmott (1933, p. 163) noted specimens in a pond at the head of Reed's Valley, Staten Island, nearly ready to transform June 17, 1931.

The average length at transformation of some specimens sent me from Raleigh, N. C., by C. S. Brimley, is 51.9 mm, the extremes 44 and 62.5 mm. The 44 mm specimens are the smallest completely transformed individuals I have had. The smallest specimens measured which had acquired the adult coloration varied from 59 to 68 mm. Grant (1931, p. 10) has indicated that coincident with the reduction of the tail fins, there is a change to be noted in the outline of the snout. In the larva it is more or less truncated while in the transformed individuals it becomes distinctly rounded.

In recently transformed specimens the ground color of the back varies from dark dull brown to black, the lower sides and venter somewhat lighter. The dorsal surface is marked with scattered light flecks, small and close together on the head, more widely separated on the trunk and tail where they are larger and tend to fuse. The light spots are at first dull dirty yellow and along each side form

a definite row extending between the legs and sometimes onto the tail.

The head is short, convex above, and with the sides rounded. The snout is short and blunt, the eyes black. The legs are flecked as on the back. The tail is irregularly flecked with small light spots of lichenlike character. At the juncture of the lower sides and belly the definite series of small, light spots sometimes fuse to form a narrow line between the legs.

Development to maturity. When larvae attain a large size before transforming, two weeks or less after leaving the water the dorsal surface becomes densely flecked with light bluish gray, most conspicuously developed on the head and trunk but in larger blotches on the tail. This general color persists only for a short time, a week or two at most, then gradually segregates to give indication of the cross bands and barred pattern of the adults. In some recently transformed specimens from Jones' pond, L. I., taken June 23, 1928, the pigment had begun to form into definite light cross bars July 5, 1928.

When transforming at a smaller size the adult color pattern is much slower in developing. Specimens from Raleigh, N. C., which had transformed about May 15th, developed sufficiently by July 22d to show the general adult pattern.

The first intimation of adult color pattern is to be noticed when the light fleckings of the back disappear along the midline and leave a fairly broad and irregular black band extending from the back of the head to the base of the tail. On either side the light areas become widened and very light bands cut across the dorsal stripe. The head generally becomes lighter at the margins but darker in a large spot back of the eyes. The tail is dark, crossed by light cross bands. In this early stage the light spots are bluish or silvery white. The legs are dark bluish and the under parts of the body bluish gray of a lighter shade.

My collections from New York localities do not include specimens at the end of the first year following transformation and the measurements that follow are taken from a series of specimens collected in a branch of the Congaree river swamp near Sumter, S. C., October 20, 1926. Since, in this region, eggs are deposited in October and November and the larvae transform in May, the individuals under consideration were approximately five months old. Seventeen specimens averaged 67.1 mm and the extremes were 55 and 79 mm. In the South the eggs are generally laid somewhat later in the sea-

son than in the North, the young transform at a smaller size and average smaller at the end of the first season. The specimens from near Sumter were all sexually immature but would, presumably, reach maturity by the fall of the year following, or when 15 to 17 months old.

Habits

General. Except during the mating season, the marbled salamander is one of the least active of all the species I have encountered. It is usually content to lie quietly when exposed and seldom makes an attempt to escape unless handled or prodded. Unlike many species, the female will often remain with her eggs when transported to the laboratory and rarely resents the disturbance. Certain salamanders, *Desmognathus fuscus* for example, will sometimes eat their eggs if disturbed while incubating but of the many females of *Ambystoma opacum* I have had under observation, only one showed cannibalistic proclivities.

This species is essentially nocturnal in its habits for during the fall months, when migrating to the breeding grounds, it is seldom found abroad during the day. Mearns (1898, p. 322), however, reported a specimen found basking in the sun but this must be regarded as an exceptional performance.

Unlike the tiger and spotted salamanders which usually burrow deeply, the marbled salamander is often content to hide beneath surface materials such as logs, bark, boards, stones and the drift piled up along the margins of streams and ponds. It is perfectly capable of burrowing for it is sometimes found well below the surface but in general is less likely to dig in than its relatives mentioned above. In seeking hiding places beneath surface materials it is more like the Jefferson salamander than our other species of *Ambystoma.*

Food. The feeding habits of the marbled salamander are not very well known. Surface (1913, p. 87) found earthworms, staphylinid beetles and undetermined insect remains in the stomachs of three individuals. The few specimens I have examined contained snails, slugs, beetles, an ant, earthworms, remains of Orthoptera, Diptera and other insects. With the food were many fragments of bark, wood and leaves, presumably taken accidentally.

Larvae are said to take small crustaceans (Deckert, 1916, p. 24). In full grown larvae from Coram, N. Y., I found the stomachs crowded with small, white, parasitic "worms." Wilmott (1933, p. 163) mentions snails of the genus *Physa* as one of the items in the diet of the larvae.

Habitat

Most writers who have commented on the habitat preferences of the marbled salamander agree that it is found in drier situations than most other species of *Ambystoma*. Thus, Cope (1889, p. 55) remarks: "This species is found in drier ground than is congenial to most salamanders. I have taken it in the sandy regions of New Jersey and Delaware." Sherwood (1895, p. 28) found that, "The adults seem to favor quite dry situations, as I have taken them from under stones lying in a sandy and gravelly path upon the top of a hill. They frequently burrow under stones which enter deeply into the soil. I have captured them as late as October 25th, and think that they hibernate very late in the fall." Mearns (1898, p. 322) writes, "It is found in dry places, as a rule, and even basks in the sun. On October 21, 1875, I caught a large one, sunning itself on a rock. A very large one was found under a stone in our garden, April 26, 1880. Another was found under a stone, near the summit of Bear Mountain, at nearly 1400 feet altitude, August 8, 1880. In digging a deep trench through dry ground, on our place at Highland Falls, one was obtained on April 10, 1880. One was found crawling on the ground in February 1872." Morse (1904, p. 107) on the other hand, writes of it as, "found under rotten logs in damp places away from bodies of water" and then adds, "It is sometimes found in quite dry regions". Ditmars (1905, p. 166) reports concerning this species, "In the adult form this salamander selects dry situations, and may be found under stones in sandy, or dry and hilly country, where it burrows to some depth." Fowler (1907, p. 41) reports, "When adult they are said to burrow in dry places, as about stones in gravelly or sandy soils." Surface (1913, p. 87) provides a discordant note and claims to have found them in small crevices or cavities near springs in August. The findings of earlier writers are supported by Engelhardt (1914), "Except during the breeding season, this species prefers dry or shady places, as already reported by Cope and others." Myers (1930, p. 100) mentions an adult from a rather dry burrow on a hillside.

I have encountered adults mostly during the egg-laying season in the fall (Bishop, 1924, p. 88) and have discussed them under the paragraph dealing with the nests. Sexually immature individuals at the end of the first season following transformation are likely to be found in the vicinity of the waters in which they were hatched. Here they hide beneath any suitable shelter such as old logs and bark, stranded boards and stones. They may wander considerable distances on occasion but in general stay where there is some evi-

dence of moisture. I have found them most numerous in the drying swamps bordering slow streams and on hillsides above ponds.

As before indicated, the larvae are found in temporary and permanent ponds, in slow streams and ditches and even in the quiet sections of streams that, in flood, have strong currents.

Remarks

The first account of the eggs of this species is that by Charles Mann in a letter to Spencer F. Baird published in the Report of the Smithsonian Institution for 1854 (1855), p. 294–95. The observations of Mann have been found to be correct in all essential details, but Pike (1886, p. 213), writing of the marbled salamander on Long Island, accuses Mann of misidentification and presents considerable misinformation on his own part. Pike found half-inch larvae in March which he believed to be *A. opacum;* but they were probably *A. tigrinum,* as suggested by Dunn (1917, p. 41). Pike also mentioned larvae 3¼ inches long taken in May which may have been *A. opacum.* Pike found eggs in the spring in water which he thought belonged to *A. opacum.* He was familiar with the eggs of *A. maculatum* so it is likely he discovered the eggs of *A. tigrinum* and failed to recognize them.

Fig. 29 New York localities for *Ambystoma opacum.*

The first evidence of spermatophores was found when a female sent to me from Mississippi was observed carrying the sperm cap and part of the gelatinous base in the posterior part of the vent. The complete spermatophore was figured and described by Lantz (1930, p. 323). Lantz (1930 *a*, p. 63) and Noble and Brady (1933, p. 98) have given the first detailed accounts of courtship and mating habits.

The type locality of this species is New York State.

Range

"From Massachusetts to Georgia, west to Louisiana and Texas, Mississippi basin north to Arkansas, Missouri, Indiana and Illinois." (Stejneger and Barbour, 1933, p. 6)

Distribution in New York

General. The lower Hudson valley from Greene county southward on the west side of the river, Westchester county on the east, Long Island and Staten Island.

Specific records. GREENE: *Coxsackie,* 1851 (Baird, 1852). NASSAU: *Baldwin,* July 25, 1911, 2 ads., (Engelhardt, 1914); *East Norwich,* Apr. 20, 1916 (Engelhardt, 1916*c*); Oct. 1, 1916, 1 ad., A. M. N. H. No. 5083; Oct. 2, 1916, 1 ad., A. M. N. H. No. 5084; *Melville,* Sept. 19, 1934, 2 ads., eggs (L. G. Barth); *Syosset,* Apr. 7, 1916, larvae, A. M. N. H. No. 16792; May 7, 1916, 2 larvae, A. M. N. H. No. 16788; May 7, 1916, larvae, A. M. N. H. No. 16783–86; May 25, 1916, larvae, A. M. N. H. No. 16787; Oct. 1918, eggs and larvae, A. M. N. H. No. 16789; March 27, 1928, larvae, (S. C. B. and J. A. W.); June 25, 1928, 2 juv., N. Y. S. M. No. 4779–4780. ORANGE: *Bear Mountain,* 1400 ft alt., Aug. 8, 1880, 1 ad. (Mearns, 1898); *Highland Falls,* Apr. 10, 1880, 2 ads., A. M. N. H. No. 5831–33 (Mearns, 1898); Apr. 26, 1880, 1 ad. (Mearns, 1898); *Kanohwahke lakes,* July–Aug. 1923, 1 ad. (G. S. Myers); *Mountainville,* Je. 13, 1920, 3 larvae, A. M. N. H. No. 12865; *West Point,* May 1918, 1 ad. (W. Robinson). RICHMOND: *Staten Island,* 1 ad. (Davis, 1884, 1908); *Reed's valley,* Feb. 1931, larvae (Wilmott, 1933). ROCKLAND: *Ramapo mountains* near *Hillburns,* June 1904, 1 ad. (W. T. Davis); *Palisades Interstate Park,* 1921, 1 ad., A. M. N. H. No. 14514 (Hyde). SUFFOLK: *Coram,* Apr. 30, 1916, larvae (Engelhardt, 1916*c*); Mar. 28, 1928, many larvae (S. C. B. and J. A. W.); June 23, 1928, 32 transforming larvae (S. C. B. and J. A. W.); Sept. 18, 1931, 1 ad. ♀ with eggs. (Noble and Brady, 1933); Apr. 3, 1931, larvae; *Lake Grove,* Sept. 18, 1931, 30 ads. (Noble and Brady, 1933); *Mattituck,* June 6, 1927, 1 ad. (R. Latham); Oct. 8, 1927, 1 ad. (R. Latham); *Deep pond,* Sept. 3, 1932, 1 ad. (R. Latham); *Melville,* Sept. 21, 1931, 33 ads. (Noble and Brady, 1933); *Miller Place,* May 1915, larvae (Engelhardt, 1916*c*); June 1, 1915, larvae, A. M. N. H. No. 16778–82; July 4, 1929, juv. (J. A. W.); Sept. 19, 1931, 1 ad. ♀ (Noble and Brady, 1933); Sept. 9, 1932, 85 ad. ♂ (Noble and Brady, 1933); Sept. 11, 1933, several ♀; *Jones' pond, Miller Place,* Sept. 3, 1922, 1 ad. ♂, N. Y. S. M. No. 9308 (Engelhardt); June 23, 1928, 6 juv. (S. C. B. and J. A. W.); Sept. 19, 1931, 83 ads. including 12 ♀ with eggs (Noble & Brady, 1933); Mar. 20, 1933, 1♂ 1♀ (G. K. Noble); *Mount Sinai,* Aug. 30, 1909, A. M. N. H. No. 16880 (Murphy); Sept. 18, 1909, ads. (Engelhardt, 1914); *Patchogue,* Apr. 30, 1916, larvae, A. M. N. H. No. 16791; *Yaphank,* Mar. 27, 1928. WESTCHESTER: *Hartsdale,* Oct.

2–4, 1931, 1♀ with eggs (Noble and Brady, 1933); *Nepperhan,* June 3, 1926 (P. Schiffer); *Silver lake* near *White Plains,* Sept. 25, 1913, 2♀ with eggs (Deckert, 1916).

Records too indefinite to be included under counties: "Observed in the western part of the State" (DeKay, 1842). This is probably an error on the part of DeKay who recorded the species on hearsay evidence. "Southern part of the State" (Eckel and Paulmier, 1902); "General in the vicinity of New York City" (Ditmars, 1905); *New York,* 1♂, 1 skel. (Boulenger, 1882); 1 ad. (Cope, 1889); 1 ad., U. S. N. M. No. 3981 (Yarrow, 1882); 1 ad., U. S. N. M. No. 39440; 1 ad., M. C. Z. No. 220; *Catskills,* (Fowler and Dunn, 1917); *Hudson Highlands,* Oct. 21, 1875 (Mearns, 1898); *Long Island,* 1881, A. M. N. H. No. 2651 (N. Pike); 1884, 1 ad., A. M. N. H. No. 5830 (N. Pike); 2 ads., A. M. N. H. No. 2347–48 (N. Pike); larvae, No. 2370–80 (N. Pike); larvae and juv., No. 2381–2446 (N. Pike); many larvae, No. 5822 (N. Pike); 1923, 2 ads. A. M. N. H. No. 11312–3 (G. P. Engelhardt); 1925, larvae, A. M. N. H. No. 24243 (G. K. Noble).

Condensed Bibliography

Life history and habits. Bishop, 1924, p. 88–89 (*Ambystoma opacum*); Brimley, 1896, p. 500 (*Amblystoma opacum*); Brimley, 1916, p. 45; Brimley, 1920, p. 25 (*Ambystoma opacum*); Deckert, 1916, p. 23 (*Amblystoma opacum*); Deckert, 1917, p. 24; Dunn, 1917, p. 40–43 (*Ambystoma opacum*); Engelhardt, 1914 (*Amblystoma opacum*); Engelhardt, 1916*c*, p. 88–89; Lantz, 1930 (*Ambystoma opacum*); Lantz, 1930*a*; Mann, 1855, p. 294 (*Amblystoma opacum*); McAtee, 1907, p. 13 (*Ambystoma opacum*); McAtee, 1933, p. 218; Mearns, 1898, p. 322; Morse, 1904, p. 107 (*Amblystoma opacum*); Noble and Brady, 1933 (*Ambystoma opacum*); Pike, 1886, p. 209 (*Amblystoma opacum*); Sherwood, 1895, p. 27; Surface, 1913, p. 87; Viosca, 1924, p. 86 (*Ambystoma opacum*).

Distribution in New York. Baird, 1852, p. 21 (*Ambystoma opaca*); Bishop, 1923, p. 68 (*Ambystoma opacum*); Boulenger, 1882, p. 41 (*Amblystoma opacum*); Cope, 1889, p. 55; Davis, 1884, p. 13; Davis, 1908, p. 47; Deckert, 1914; Deckert, 1916, p. 23; Deckert, 1917, p. 24; DeKay, 1842, p. 77 (*Salamandra fasciata*); Ditmars, 1905, p. 166 (*Amblystoma opacum*); Dunn, 1917, p. 40 (*Ambystoma opacum*); Eckel and Paulmier, 1902, p. 398 (*Amblystoma opacum*); Engelhardt, 1914; Engelhardt, 1916, p. 88; Fowler and Dunn, 1917, p. 9 (*Ambystoma opacum*); Mearns, 1898, p. 322; Myers, 1930, p. 100; Noble, 1927, p. 2; Noble and Brady, 1933, p. 90; Pike, 1886, p. 20 (*Amblystoma opacum*); Sherwood, 1895, p. 27; Wilmott, 1933, p. 161 (*Ambystoma opacum*); Yarrow, 1882, p. 147 (*Amblystoma opacum*).

General. Baird, 1850, p. 283 (*Ambystoma opaca*); Holbrook, 1842, p. 71 (*Salamandra fasciata*); Stejneger and Barbour, 1933, p. 6 (*Ambystoma opacum*).

AMBYSTOMA TIGRINUM TIGRINUM (Green)

(*Salamandra tigrina,* Jour. Acad. Nat. Sci. Phila. 1825, 5: 116)

Tiger Salamander

Figures 2*f*, 4*g*, 30–32, 33*a–c*, 34

The tiger salamander, in its several races or varieties, is the most widely distributed member of *Ambystoma* in the United States but in New York is now apparently restricted to the lower Hudson valley and portions of Long Island. Its development has been very intensively studied because of the interest aroused by the discovery

that in certain parts of its range and under some conditions, the gills and other larval structures are retained, the animal reaching sexual maturity and breeding in this condition. The larvae attain a size much larger than that of any other species of the genus in the North and a few show a tendency, under laboratory conditions at least, to remain in the larval condition for a considerable period; but they neither attain the size nor the sexual maturity of the axolotl of Mexico and of some of the high lakes of Colorado.

While it is likely that several distinct races will be recognized, the New York State representatives of the species present the characters of the type form.

Description

Size. The tiger salamander grows to a larger size than any other species of the genus in the State and is exceeded only by the mudpuppy, *Necturus,* and the hellbender, *Cryptobranchus.* The number of adults collected in the State is few compared with other members of the genus, and my own collections give very little idea of the size range of the species.

The eastern race has been studied by Uhlenhuth (1921, p. 354), however, and some idea of the growth rate and size attained may be had from his paper. The largest individual reared from the egg had attained a length of 200 mm at the age of 84 months (weeks?) and was still growing slowly. A specimen of the eastern form in the American Museum of Natural History had a total length of 208.8 mm (*ibid.* p. 358). The largest specimens of the eastern form in the U. S. National Museum were 223 and 235 mm long (*ibid.,* p. 362). Cope (1889, p. 70) records a specimen from Racine, Wis., 10 inches or 254 mm in total length. A male and female from Miller Place, Long Island, sent to me by G. K. Noble measure 208 and 175 mm respectively. Engelhardt (1916, p. 20) records the measurements of three specimens as follows: Syosset, Nov. 1911, 8½″ (209 mm); Yaphank, Aug. 24, 1915, 8⅛″ (206 mm); Shoreham, Sept. 24, 1915, 7½″ (190 mm). The sex of these individuals was not indicated.

In a series of 50 adults from Long Island, measurements of which were supplied by Dr G. K. Noble, the 22 males average 202 mm and the 28 females, 177 mm in total length.

Form. The body is stout and muscular in well-fed individuals but becomes angular and rangy in specimens kept in captivity and underfed. The skin in life is fairly smooth but in preserved specimens is inclined to be rougher than that of our other local species.

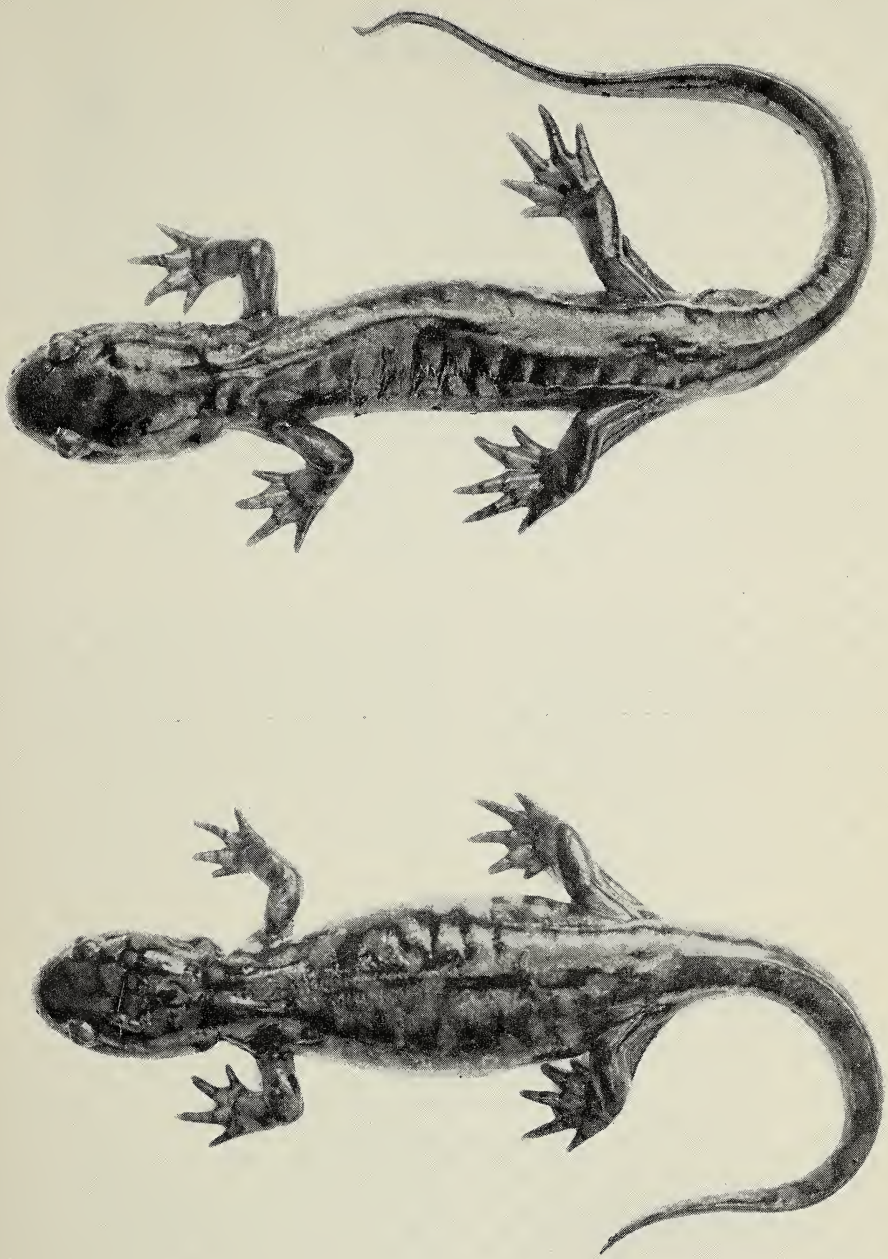


Fig. 30 *Ambystoma t. tigrinum.* Adult female (lower) and male from Miller Place, N. Y., Mar. 20, 1933.

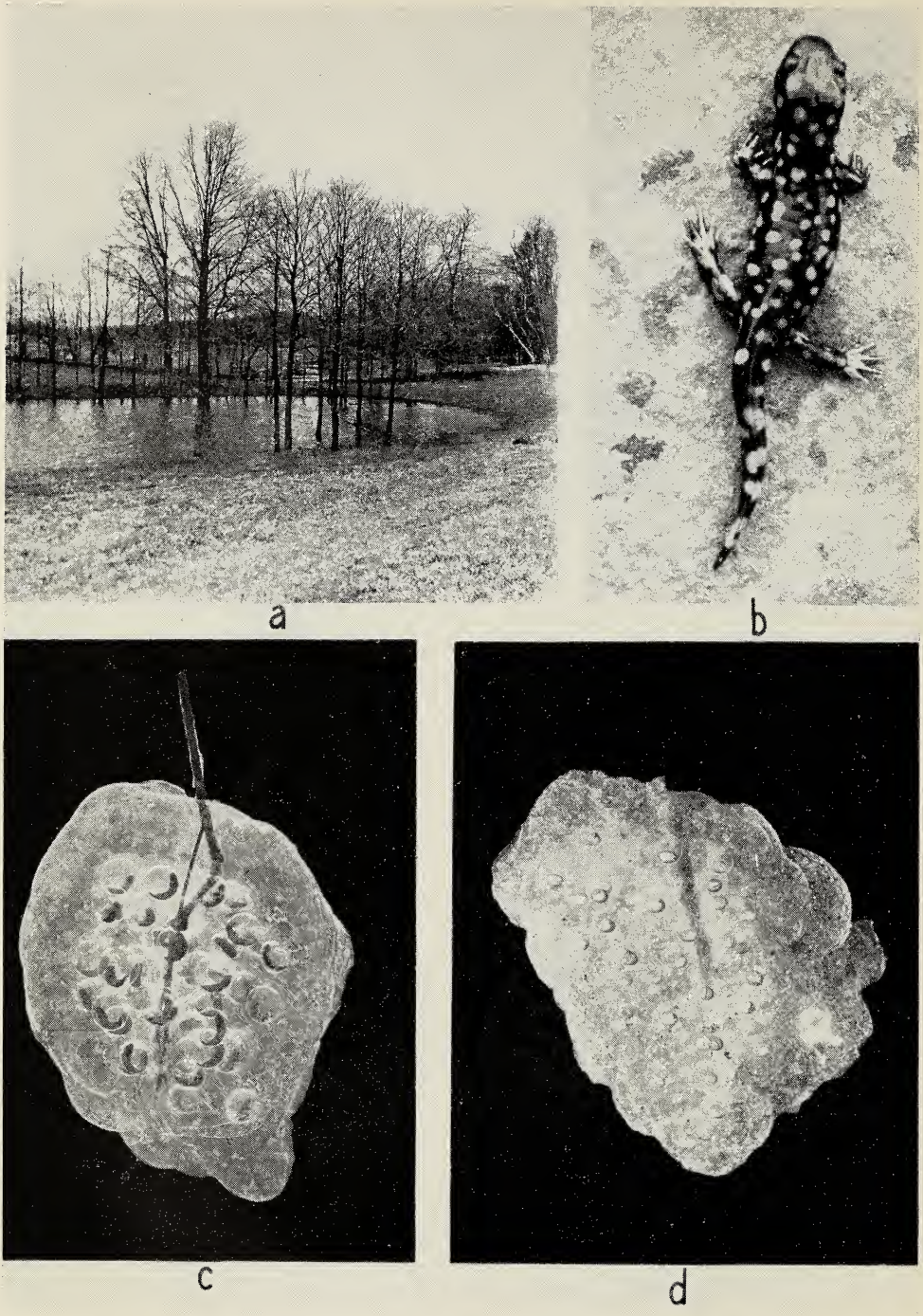


Fig. 31 a. Temporary pond on the Hudson estate near Syosset, N. Y., Apr. 4, 1926. Breeding place for *Ambystoma t. tigrinum*. b. *Ambystoma t. tigrinum*, about one month after transformation. Syosset, N. Y. Actual length, 90 mm. c. Typical egg cluster with embryos well advanced. Syosset, N. Y., May 3, 1926. d. Eggs in neural groove stage, Coram, N. Y., Mar. 28, 1928.

The head is broad, widest just back of the eyes opposite the angle of the jaws and tapers gradually to the sharply constricted neck. The snout is broadly convex and bluntly rounded in front. The well-developed gular fold extends vertically on the side of the neck where it joins a longitudinal groove running to the eye. At the angle of the jaw a short groove bends upward and forward to meet the horizontal groove back of the eye. The eye is only moderately large and not so strongly protuberant as in some species of the genus. The iris is tinged with gold or yellow and the pupil is black.

There are 12 costal grooves counting axillary and inguinal, but often the axillary is lacking, leaving 11 well defined and about evenly spaced. The legs are stout and relatively short, the five toes in order of length, 1-5-2-3-4. On the front feet the order is 1-4-2-3 with the fourth and first almost equal. The toes are strongly depressed, rather short and tapering to blunt tips. Palmar and plantar tubercles are two in number and conspicuous.

The tail is about three-fourths as long as the head plus the trunk to the posterior end of vent. It is nearly oval in section near the base, thicker below than above and compressed more and more to the tip.

The tongue is broad and fleshy with the margins only, thin and free. At the hind part of the tongue, the papillose section forms a transverse band shallowly emarginate posteriorly. The palatine teeth form a sinuous line extending across the roof of the mouth from one side of the jaw to the other. The teeth are usually in a single continuous series but sometimes are narrowly interrupted at the middle point. In some specimens, the teeth on either side of the midline form two broadly convex arcs; in others three shorter arcs are formed on each side, with the central part of the arc back of each inner naris and the middle arc between them. In the specimens I have examined there is no break in the series back of the inner nares as in the other species of the genus found in the State.

Color. The ground color above and on the sides is deep brown or dull black. On the lower sides the dark color meets the lighter olive-yellow of the venter in a highly irregular fashion, with often the lighter markings extending upward between the costal grooves in short broad bars. The ground color is marked with numerous, pale, brownish olive or brownish yellow blotches irregular in size and shape and tending to fuse and form bands on the lower sides and tail in some individuals. The under side of the head is often quite uniformly yellow or yellow tinged with olive. The olive-yellow

venter is blotched and marbled with a darker shade, particularly along the middle of the belly between the fore and hind legs. In some individuals the dark markings predominate on the lower surface of the tail, in others this area is uniformly lighter.

The only salamander in the State with which the tiger might be confused is the spotted salamander. In the tiger, the light spots are much more numerous, more irregular in size, shape and distribution, and usually much duller in color.

Sexual differences. The most strongly marked sexual differences are to be noted in the vent which, in the male, has the opening much longer than in the female and, during the breeding season, is bordered each side by the greatly swollen cloacal glands. The tail of the male is proportionally and actually longer than in the female in the few specimens I have examined, and the hind legs somewhat longer and stouter. Engelhardt (1916*a*, p. 21) remarks that, "of four living specimens . . . two males and two females, the latter are marked with blotches decidedly more olive-yellow than those of the males."

Activities of the Breeding Season

Migration. The spring migration to the breeding ponds on Long Island takes place in March sometimes as early as the first week but usually nearer the middle of the month. Often the ponds are reached before they are entirely free from ice but along the margins there are stretches of open water into which the salamanders make their way.

The migration is initiated by rains, so far as my observations go, and on occasion, the salamanders may be found in the water which has collected on the surface of the ice. It is evident that the majority of individuals migrate at night, for during the day some may be found hiding beneath old logs, bark and other surface debris.

Mating. Observations on the courtship of *A. tigrinum* under laboratory conditions have been reported by Kumpf (1934, p. 7), and the following paragraphs have been condensed from her account.

Males and females in breeding condition were placed together in a tank containing about six inches of water and observed by the aid of photographers' red bulbs.

The activities began soon after the introduction of the animals into the aquarium. After walking and swimming about they began to

nose and push one another and, as in *A. opacum,* the sexes at first were nosed indiscriminately. Kumpf observes:

The butting was not localized but in the majority of cases the male thrust his snout into the side or midventral region of the other salamander and would often swim around for several minutes holding the individual balanced on his head. After a time the nosing of the male took on some direction. After thrusting his snout into the side of the female and tossing her about he sometimes worked forward to her head and then retreated to her cloaca. In other instances he proceeded immediately to the latter region. Butting the cloaca was vigorous and often resulted in the male's lifting his companion to the surface of the water. . . . Finally the male would stalk ahead for a short distance and deposit a spermatophore while rubbing his cloaca on the aquarium floor. A striking position not reported for any ambystomids except *A. jeffersonianum* was assumed by the male during this process. All feet were raised from the bottom of the tank and rigidly outstretched. His body was convulsed and his tail, raised at right angles to his body, undulated violently. When the courted animal was a female and sufficiently stimulated by the male's attention her snout was closely applied to his cloaca at this time. As he advanced after deposition she followed him with her nose still close to his cloaca and passed her body over the spermatophore until her vent was immediately over it. Then she assumed the identical position taken by the male during the production of a spermatophore.

Apparently, in the case of the tiger salamander, spermatophores may be deposited by the male without preliminary courtship activities immediately preceding, but the female exhibits little interest in a spermatophore unless it is produced during the height of the courtship.

The egg mass. The egg mass when first deposited is small and compact but with the absorption of water may increase to a size equaling that of the smaller masses of the spotted salamander. When the embryos have become well advanced in development, the mass may increase to a size exceeding that of any spotted salamander and become exceedingly soft and tenuous.

The fused outer envelops, which together make up the common jelly layer surrounding the eggs, are usually less compact than that of *A. maculatum* and the mass tends to slip from the support when lifted from the water. This is particularly true of the older masses. In its consistency, the freshly deposited jelly mass is about intermediate between that of the Jefferson and spotted salamanders.

The egg mass is fastened to twigs, weed stems or some similar support well below the surface of the water. In a few instances, I have found them within six inches of the surface but usually they are placed at a depth of a foot or more below.

The mass may be nearly globular, oblong or kidney-shaped and at the time of hatching measure as much as 75 mm in width by 100 mm in greatest length. The majority of masses, however, are smaller, the average about 55 x 70 mm.

The number of eggs to the mass is variable but the average is always less than that of *A. maculatum* and two or three times that of *Ambystoma jeffersonianum*. In nine typical masses collected April 4, 1926, at Syosset, L. I., the eggs numbered respectively 23, 25, 26, 26, 29, 31, 54, 62 and 76, an average of 38 eggs to a mass. The mass containing only 23 eggs, which were in an advanced stage of development, had a long diameter of 90 mm and a short diameter of 46 mm. A single egg mass deposited late in the season after the larvae had hatched from those laid earlier, contained 43 well-developed embryos on May 3 (figure 31c). It is unusual to find unhatched eggs this late date although in the collections of the American Museum are day-old larvae labeled as having been taken May 7, 1916, and Engelhardt (1916*b*, p. 51) records the discovery of unhatched embryos on May 9, 1916.

Although the number of eggs to a mass is usually small, occasionally one is found that contains almost twice the average. On March 28, 1928, two lots collected at Coram, L. I., contained 101 and 86 eggs respectively, and on March 31, 1932, a single mass with 60 well-developed embryos. Engelhardt (1916*b*, p. 49) counted the eggs in several masses obtained at Syosset in which the smallest contained 30 and the largest 110. The 14 egg masses from Long Island localities of which I have definite counts contained a total of 729 eggs, or an average of 52 eggs to a mass.

Compared with the egg mass of *A. maculatum*, that of *A. tigrinum* has the external layer relatively thicker but less dense, the eggs fewer in number, the envelops less likely to be milky and the individual egg-envelops with a greater diameter.

Development

The egg and its envelops. The individual egg has a diameter of about 3 mm. The animal pole varies from light to dark brown and the vegetal pole from pale cream to buff. In the freshly deposited eggs the envelops are disposed about as follows although the relative thickness varies slightly in different lots of the same age and greatly during the progress of development. In addition to the vitelline membrane there are three distinct envelops visible in the fresh egg. This does not take into account the outermost layer which fuses with that of other eggs to form the common covering.

When the egg itself has a diameter of 3 mm the layer next without measures about 4 mm. This layer is composed of thin clear jelly. The middle layer is very thin, about the same density as the inner and is apparent only in fairly fresh eggs. The third layer varies in diameter from 6 to 8 mm and may expand at the time of hatching to a maximum of 10 mm. This layer is also composed of thin, clear, transparent jelly and often becomes elliptical.

The incubation period. Under laboratory conditions, at a room temperature of 68° to 70° F., larvae hatch in from 12 to 18 days. Engelhardt (1916*b*, p. 51) reported that the hatching period under natural conditions out-of-doors appeared to vary between 30 and 40 days, subject to weather conditions. This estimate seems to me somewhat high, and I am inclined to believe that 30 to 40 days normally encompasses the period from the first deposition of eggs until those last deposited have hatched. In some years, however, the egg-laying season is extended to cover a period of at least a month. In 1926 the first eggs of the season were deposited during the last week in March and embryos in an advanced stage of development were collected April 4th. On May 3d others equally advanced were taken in the same ponds. In 1916, Engelhardt (*ibid.*) collected eggs at Syosset on April 7th, and others, still unhatched, on May 9th.

For additional records of the tiger salamander from Long Island I am indebted to Dr Eduard Uhlenhuth, whose history of the species covers seven different years.

LOCALITY	COLLECTED	HATCHED	METAMORPHOSED	TEMPERATURE
Syosset.....	Apr. 24, 1917	Apr. 28	July 8 to 26	23.5 C aver.
Syosset.....	Mar. 23, 1919 (early cleavage)	Apr. 2	June 27 to July 3	23.5 C aver.
Syosset.....	Apr. 6, 1919	Apr. 11	June 11 to 20	23.3 C aver.
Syosset.....	Mar. 13, 1921	Mar. 23	Aug. 15 (one)	15.0 C
Cold Spring Harbor	Apr. 5, 1923	about Apr. 15 (artificially retarded)	June 21 to 23 (three)	.....
Cold Spring..	Apr. 1, 1924	Apr. 6 to 9	.....	25.0 C approx.
Syosset.....	Apr. 4, 1926	Apr. 14	July 23; Aug. 3, 13, 14; some still larvae Aug. 27.	variable
Coram and Syosset	Mar. 28, 1928	Apr. 10	Aug. 7, 13, 28	.....

Eggs collected by Engelhardt April 7th, and presumably laid not earlier than April 1st, hatched April 18th to 22d, an average hatching period of 20 days, seven under natural conditions out-of-doors and 14 in the laboratory, at an average air temperature of 65° F.

Some eggs taken March 22, 1927, at Syosset, by Engelhardt, were in an advanced stage of development and others had apparently already hatched at this early date. On March 30, 1927, I collected additional clusters at the same locality and these hatched at room temperature beginning April 15th, a period of incubation of 16 days in the laboratory in addition to several in the pond.

The newly hatched larva. The newly hatched larvae vary in length from 13 to 17 mm and average about 14 mm. The head is broad, widest just in front of the gills and rounding to the short and blunt snout. The eyes are large and well developed with the iris brassy, speckled with black. The gills are as long as the head but with comparatively few filaments. The dorsal fin originates just back of the head and reaches its greatest width at a point opposite or slightly behind the vent. The balancers are lacking at hatching but Nichols (1925, p. 191) while studying midwestern material, found a rudimentary, nonfunctional and transitory balancer in some embryos. In most larvae I have examined there has been no indication of the limb buds; in a few the buds of the fore limbs are represented by low rounded humps. The body is long, slim, tapering and strongly compressed.

The ground color above is yellowish green with darker markings. There is a median dark band which originates on the snout, widens on the head and continues along the trunk on each side of the dorsal keel. On the head, back of the eyes, is a pair of pale spots with short, narrow extensions running above the gills and less conspicuous pale spots at the base of the third pair of gills. The dorsal band on the trunk is usually broken to form about six pairs of dark spots with lighter interspaces. On the upper sides but below the dorsal series, is a light band in which the chromatophores are in scattered patches forming faint irregular spots; on the lower sides is a dark band running from the gills to the vent. The keels of the tail are lightly pigmented with scattered chromatophores.

Viewed from the side, the most striking feature is the strongly banded appearance. The middorsal series of paired spots appear as a broken band, below which is the lighter band extending from the eye well on the tail. Below the light band the broad pigmented area extends from the head to the base of the tail and encroaches slightly on the belly.

Larvae from different egg masses vary considerably at hatching, both in color pattern and in degree of development. I have measured a series of larvae that averaged only 12.8 mm in length and

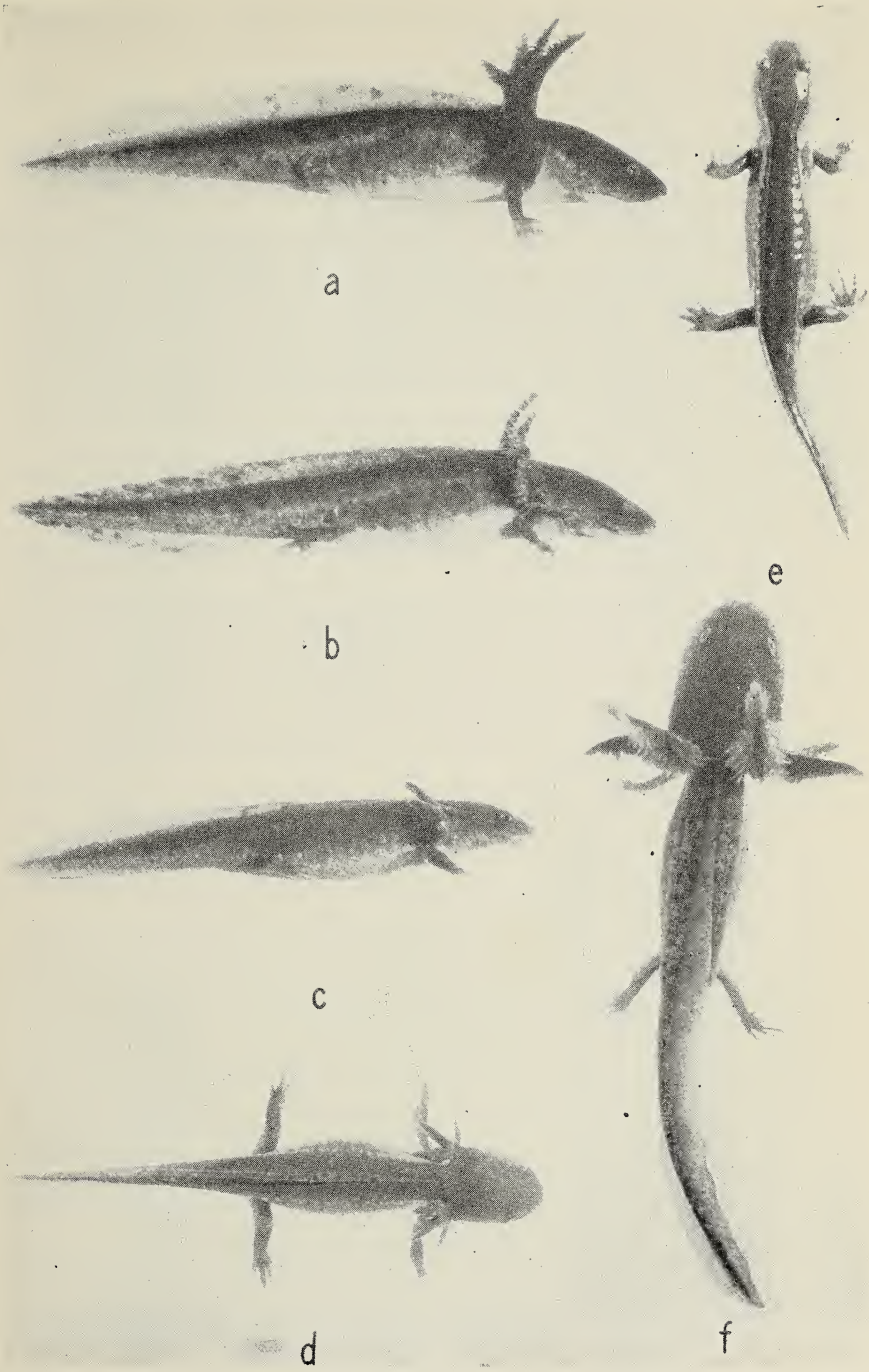


Fig. 32 a. Full-grown larva of *Ambystoma t. tigrinum*, Syosset, N. Y., June 25, 1928. Actual length 121 mm. b. Larva with tail fin slightly reduced and gills shortening. Same data as above. c. Larva with shortened gills and reduced fins, Aug. 1, 1927. d. Same, dorsal view. e. Recently transformed young. Aug. 8, 1927. f. Dorsal view of specimen shown in a. E. J. S., photo.

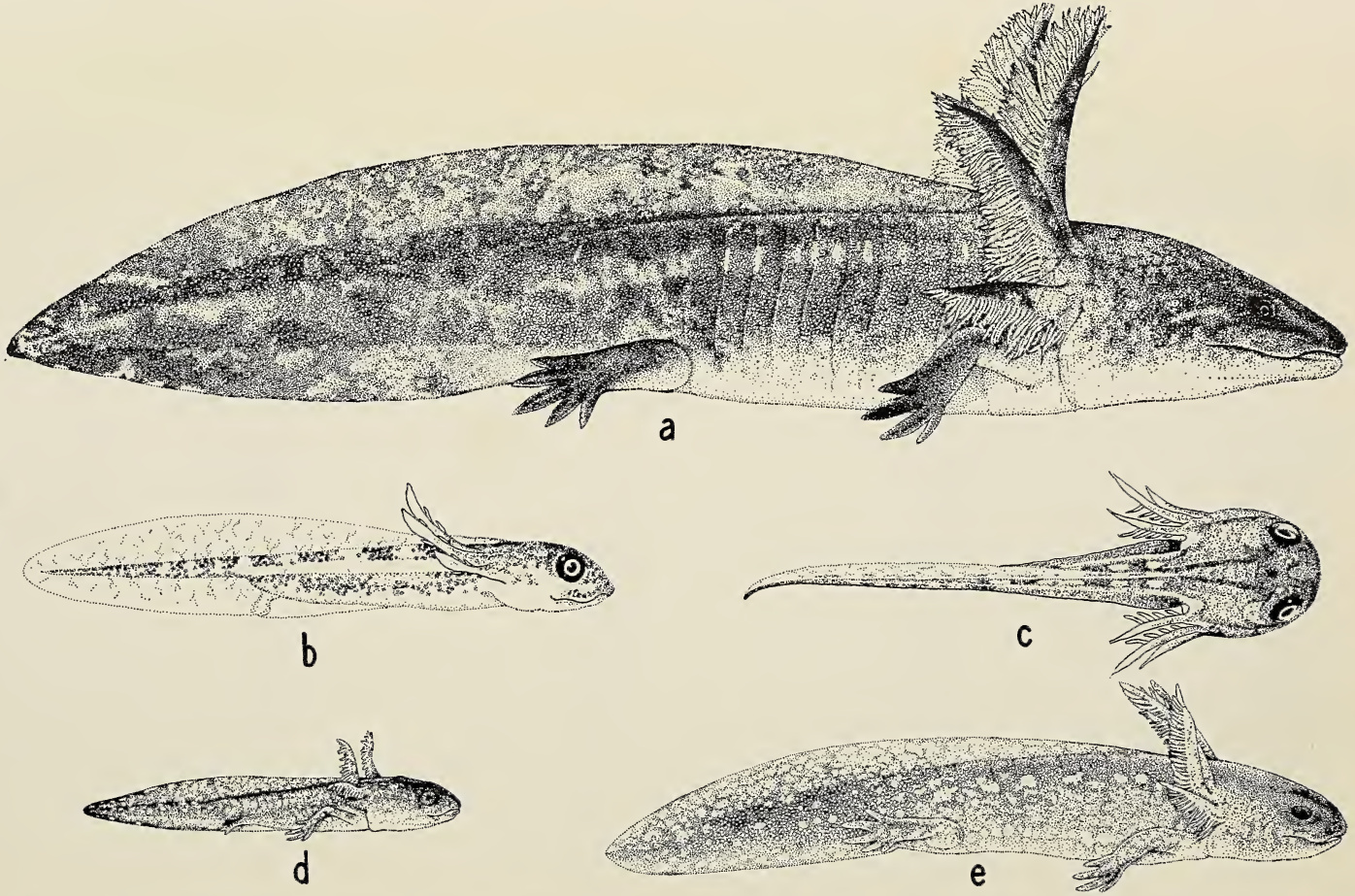


Fig. 33 a. *Ambystoma t. tigrinum*, full-grown larva, Syosset, N. Y., June 22, 1928. Actual length 121 mm. H. E. R., del. b. Recently hatched larva, Coram, N. Y., Apr. 4, 1932. Actual length, 14.5 mm. H. P. C., del. c. Same, dorsal view. d. *Ambystoma opacum*, half-grown larva, Coram, N. Y., Mar. 28, 1928. Note short hind limbs. H. E. R., del. e. Same, full-grown larva, actual length, 66 mm.

varied from 12 to 15 mm. In these the color pattern on the head consisted of a few scattered chromatophores on a general ground color of dull greenish yellow. Along each side of the dorsal fin the dark spots were represented by clusters of separate chromatophores and on the lower sides the dark band was less pronounced. In these there is no indication of fore limb buds.

Length of the larval period. In 1928 when eggs with well-developed embryos were collected March 28th, at Syosset, the larvae hatched in the laboratory April 10th. In the field, some abandoned egg masses gave evidence that some larvae had already hatched at the time the eggs were collected March 28th. On June 22d and 25th fully developed larvae were found in the same ponds at the Hudson Estate and if the eggs that produced them hatched about the first week in April, the larvae were 73 to 75 days old. How long they might have continued in the ponds as fully grown larvae without transforming, I have no way of knowing. Those reared in the laboratory by Dr Eduard Uhlenhuth transformed August 7th, 13th and 28th, a period (from April 10th) covering 119 to 140 days.

In 1927 some eggs collected at Syosset March 30th hatched April 15th and the larvae reached their full development August 1st. These larvae transformed August 11th after a larval period of 118 days.

The field and laboratory studies of this species by Engelhardt have provided additional records of transforming larvae and the following notes are condensed from his account (1916*b*, p. 32): on May 31, 1915, larvae 2 to 3 inches long were found in a muddy Syosset pond and a few 2 to 4 inches long in a deeper and clearer pool. On June 15th, 9 larvae 3 to 3½ inches long were taken in the muddy pool and 6 larvae 2½ to 4 inches long in the clear pool. On June 19th the largest larvae measured 4½ inches and the gills were beginning to be absorbed. A third visit to the Syosset ponds on June 21st resulted in the capture of ten larvae in the muddy pools, varying in length from 3 to 4 inches.

Specimens in captivity continued to absorb the gills rapidly from June 24th to July 12th when only traces remained, and the tail fins had disappeared. By July 20th the gill slits had entirely closed and yellow blotches began to appear. Metamorphosis was regarded as completed August 15th.

Mature larvae. Twenty-one fully grown larvae taken June 22, 1928, at Syosset varied in total length from 90 to 123 mm and averaged 106.7 mm. Seventeen of the 21 larvae measured 100 mm

or over, with eight exceeding 110 mm. In the largest specimens the tail keel was 25 mm in greatest width but among the smaller specimens the range was from 18 to 22 mm.

Larvae that have reached maturity in their native ponds where the rotting leaves of the bottom provide a somber background, have a ground color deep brown or almost black. On the tail keels strong blotches of yellow and orange form a mottled pattern over the darker ground while along the sides of the trunk and tail a series of pale spots, more or less connected, form an indistinct band. The belly is silvery yellow, the throat with tinges of bluish.

The dorsal keel originates at the back of the head and extends in a broad sweeping curve to the tip of the pointed tail. Ventrally the tail keel is narrower and extends to the vent. The long and beautifully fringed gills are carried as a neck piece of plumes, the hindmost thrown forward over the head. The legs are long and strong with the toes pointed and flattened. The head is broad and sharply depressed from a point above the gular fold to the bluntly rounded snout. The eye is only moderately large with the iris forming a narrow golden ring. The body itself is deep, the head somewhat convex and less flattened than in *A. maculatum* or *A. jeffersonianum.*

Larvae reared in a laboratory aquarium are dull greenish brown above with the sides of the head, lower sides of the trunk and tail with irregular blotches of dull yellow over deep brown or black. On either side, extending from the head and well on the tail, are indistinct light spots forming a faint stripe. The belly is silvery between the legs and tinged with fleshy.

Transformation. In the recently transformed individual the ground color above is dark gray or dark brown, the basal joints of the legs, the lower sides and tail are a little lighter. The mid-dorsal line of the trunk and head is uniformly dark but the sides of the head below the line of the mouth, the lower sides of the trunk and the sides of the tail are lightly and irregularly blotched. The throat is dusky white and the belly, and under surface of the tail, bluish gray.

The characteristic yellow blotches of the adult which are so faintly foreshadowed in the recently transformed individual, reach their full development only at maturity. A month or so after transformation, the light blotches are small, bright and well separated; and it is only by the expansion and coalescence of these light areas that the adult coloration is finally developed.

Specimens reared by Engelhardt (1916*b*, p. 34) and which transformed August 15th, attained a length of 135 mm (5 5/16 inches) by September 13th. On October 18th a length of 149 mm (5⅞ inches), had been reached and by February 17th the largest measured 152 mm (6 inches).

Development to maturity. The exceptionally large size attained by the larvae during the single season in the ponds and the rapid growth subsequent to transformation, as shown by the measurements given above, indicates that sexual maturity may be reached the spring following transformation.

In captivity, at least, the species is long lived. F. C. Blanchard (1932, p. 98) mentions a male reared from eggs hatched in the laboratory in the spring of 1920 and kept in confinement until July 1931, when it died. In 1924 an adult female was collected and was still living when the note was published in 1932.

Habits

General. The adults are nocturnal and much given to burrowing. This is attested by the fact that when found during the summer and fall they are in deep burrows, beneath manure piles or in drains that have been followed considerable distances from the breeding ponds. In their nocturnal ramblings, particularly in the fall, when seeking places to hibernate they sometimes enter cellars or tumble into basement-window wells. A considerable number of specimens on Long Island have been found in catch-basins on the old Hudson Estate near Syosset (Engelhardt, 1916, p. 21).

In general, it may be said that the Long Island adults at the breeding season visit temporary pools although exceptions may be noted. At Coram they are to be found in pools of the most ephemeral character and in permanent ponds. At Syosset I have never found the larvae in the one permanent pond on the Hudson Estate while the meadow and woodland pools abound with them. The absence of the larvae in the permanent pond at Syosset may be due to the presence of fish.

Food. Detailed studies of the food of the tiger salamander in New York have not been reported. Ditmars (1905, p. 168) listed insects, worms and very young field mice among the food items. Hay (1892, p. 434) confined a specimen in a cage with *Acris* and a large caterpillar, both of which disappeared, and the following morning the salamander was found holding a good-sized *Hyla versicolor* by one foot. Engelhardt (1916*b*, p. 51) listed *Daphnia* and

other small aquatic organisms as items in the diet of the young larvae and (1916*b*, p. 34) earthworms as suitable food for the recently transformed. The adult animals feed readily on earthworms, tadpoles, small fishes and caterpillars. Hay (1889, p. 602) found that the adults took earthworms, frogs, insects, tadpoles, fresh beef and other salamanders. Certainly they are cannibalistic as well as carnivorous for smaller larvae confined with the older members disappear one after another.

Habitat

On Long Island, the tiger salamander not only resorts to the breeding ponds that lie in the region about Syosset where the forest cover is of the mixed deciduous type, but to the more sandy and barren ponds that are found in areas about Coram. Whatever the factors may be that determine the distribution of the species, the presence of suitable breeding ponds and conditions permitting burrowing seem to provide for its continued existence. Throughout its range—and I have collected representatives of the species from near sea level on Long Island to the mountain lakes of Colorado—the surface features of its environment are so extremely diverse that one is inclined to the belief that it survives because of its habit of burrowing. Well below the surface of the ground, temperature and humidity remain relatively constant and well below the surface it remains most of the year, at least in the northern parts of its range, and elsewhere if the climate is hot and dry. The possibility that the animal may supply its own environment may well account for the persistence of the species in regions that appear unsuitable. Engelhardt (1916, p. 20) mentions a specimen reported by Dr Frank Overton, as having been taken in a salt marsh near Swan creek, Long Island.

In some of the ponds at Syosset, the tiger salamander is in competition with *A. maculatum, A. opacum,* the newt, *Triturus,* and a considerable number of frogs and toads. The marbled salamander usually has the advantage of hatching in the fall and the larvae attain a considerable size by the time the tiger salamanders arrive at the breeding ponds. The larvae of *A. opacum,* however, are soon exceeded in size by those of the tiger salamander and by June the latter may attain a length in excess of 100 mm, or twice that of *A. opacum.*

I have collected the eggs of *A. maculatum* and *A. tigrinum* in the same ponds but, when seining for larvae, recovered only those of

the tiger; and it would indeed be remarkable if the smaller and slower growing *A. maculatum* larvae long survived in the presence of those of the tiger. Newts apparently thrive in spite of the competition, for I have seined many from ponds where earlier in the season the tiger larvae were exceedingly abundant.

Remarks

The range of the tiger salamander in New York State formerly included the region about Albany. James Eights in his interesting natural history notes published in The Zodiac in 1835 and 1836, apparently gave the first record of the species in the State. In Volume I, page 132 is the following: "May 28, 1835. A fine specimen of the *Salamandra tigrina,* Green, was brought to me today, having been taken within a few miles of the city. This is the second specimen yet found as far north as this, measures seven inches in length, the first was caught in our streets, having been brought to the city in a hollow piece of wood down the Erie Canal." In the absence of any other record of the species from the Albany region, one might question the identification were it not for the fact that one of the two specimens was presented to the old Albany Institute and subsequently sent to the New York State Museum bearing the time-worn label, "Erie Canal, Dr Jas. Eights." The specimen is still in the collections of the State Museum.

The account of the development of *Amblystoma lurida* given by Hoy (1871, p. 578) has been regarded by some as referring to the tiger salamander, and without much doubt it does, at least in part. In the description of the recently hatched larvae, however, "holders" are mentioned which may indicate that larvae of another species were also involved.

The sight record of a specimen at Jamesville, Onondaga county, by Britcher (1903, p. 120), is open to question and the statement of Eckel and Paulmier (1902, p. 399) that the tiger salamander is found, "All over the state" is, of course, incorrect. It has never been found all over the State. There may be some value in the report of DeKay (1842, p. 83) that the species was found at Oneida lake, New York. There have been reports, in recent years, of large spotted salamanders being found in that vicinity and from the descriptions given, it was apparent *A. maculatum* was not being confused.

The tiger salamander has been liberated on Staten Island (Wilmott, 1933) and in two ponds in the vicinity of Albany, N. Y. Whether or not it has become established at Albany, is not known.

Sherwood (1895, p. 28) commenting on the tiger salamander remarked: "All specimens received by me were from a pond near Rancocas, L. I.," but Engelhardt points out (1916, p. 20) that the name "is a misprint as no such place exists on Long Island. Sherwood admits this, yet in reasserting the occurrence of the species he prefers to withhold the right name of the station, fearing extinction."

Range

From Long Island southward to northern Florida, westward to Mississippi and Arkansas and northward to Minnesota and Ontario.

Fig. 34 New York localities for *Ambystoma t. tigrinum.*

Distribution in New York

General. Formerly occurred as far north as Albany and possibly west to the vicinity of Oneida lake (DeKay, 1842, p. 83) but now apparently restricted to Long Island and Rockland County.

Specific records. ALBANY: *Albany,* May 28, 1835, 1 ad. (Eights, 1836). NASSAU: *Syosset,* Nov. 1914 (Engelhardt, 1916); May 1, 1915, A. M. N. H. No. 16763; May 21, 1915, A. M. N. H. No. 16762 (G. P. Engelhardt);

May 31, 1915 (Engelhardt, 1916); June 15, 1915, 2 larvae, A. M. N. H. No. 10759–61; June 21, 1915, 1 larva, A. M. N. H.; June–July 1915, A. M. N. H. No. 16765; Apr. 7, 1916, eggs, A. M. N. H. No. 16775–77; Apr. 18, 1916, eggs, A. M. N. H. (Engelhardt, 1916); May 7, 1916, larvae, A. M. N. H. No. 16774; June 1, 1916, many larvae, A. M. N. H.; July 5, 1923, 1 yg. ad., A. M. N. H. No. 20,149 (G. K. Noble); Apr. 4, 1926, eggs, N. Y. S. M. No. 3039 (S. C. B., G. P. Engelhardt and W. J. S.); Mar. 30, 1927, eggs, N. Y. S. M. No. 4693; Mar. 1927, eggs (Davis, 1928); Mar. 27, 1928, eggs; June 22, 1928, 21 large larvae (S. C. B. and J. A. Weber); June 25, 1928, 6 large larvae, N. Y. S. M. No. 4777–4778; ads., Mar. 29 and Apr. 1, 1932 (G. K. Noble). *Setauket,* Mar. 24, 1935, 1 ♂, 1 ♀, eggs (L. G. Barth). ONONDAGA: *Jamesville* (Britcher, 1903) (doubtful record). QUEENS: *Jamaica,* Oct. 1915 (Engelhardt, 1916); *Richmond Hill,* 1891, 3 larvae, A. M. N. H. No. 2638–2640 (E. Smith). ROCKLAND: *Suffern,* Dec. 9, 1896, 3 spec., A. M. N. H. No. 2327 (W. A. Chapman). SUFFOLK: *Coram,* Mar. 28, 1928, eggs, U. R. No. 3281 (S. C. B. and J. A. Weber); Sept. 1931, 1 ad. (E. Hawkins); ads., Mar. 29 and Apr. 1, 1932 (G. K. Noble); Mar. 31, 1932, eggs and larvae (S. C. B. and H. Chrisp); sev. ads. Mar. 1933 (Kumpf, 1934); *Laurel,* May 1, 1925, 1 ad. (R. Latham); *Manorville,* Mar. 25, 1933, 1 8-in. spec. (A. Dart); *Melville,* Mar. 29, and Apr. 1, 1932 (A. M. N. H.); *Middle Island,* Oct. 10, 1915 (Engelhardt, 1916); July 8, 1923, large larvae, A. M. N. H. No. 18,673; Mar. 29 and Apr. 1, 1932 (A. M. N. H.); Aug. 10, 1938, larvae abdt.; between *Middle Island* and *Yaphank,* July 9, 1925, large larvae, A. M. N. H. No. 23251–57 (G. K. Noble); *Miller Place,* Mar. 29, and Apr. 1, 1932 (A. M. N. H.); Mar. 20, 1933, 1 pair (A. M. N. H.); *Patchogue* (Engelhardt, 1916); *Shoreham,* Sept. 24, 1915 (Englehardt, 1916); *Sweezytown,* Mar. 29, and Apr. 1, 1932 (A. M. N. H.); *Yaphank,* Aug. 24, 1915 (Engelhardt, 1916); Mar. 27, 1928, eggs.

Records too indefinite to be placed under counties. *New York,* (Yarrow, 1882; Cope, 1867, 1889); "all over the state" (Eckel and Paulmier, 1902); 1 spec., U. S. N. M. No. 3956; *Long Island,* July 1895 (A. M. N. H.); rare on Long Island (Ditmars, 1905); 1925, larva, A. M. N. H. No. 23,391; 1925, larvae, A. M. N. H. No. 24,242 and 24,239 (G. K. Noble); ads., A. M. N. H. No. 2328–2330 (N. Pike); near *New York City* (Allen, 1869); vicinity of *Oneida lake* (DeKay, 1842).

Condensed Bibliography

Life history and habits. Blanchard, F. C., 1932, p. 98 (*Ambystoma tigrinum*); Cope, 1889, p. 83 (*Amblystoma tigrinum*); Ditmars, 1905, p. 168; Engelhardt, 1916, p. 20; Engelhardt, 1916*a*, p. 32; Engelhardt, 1916*b*, p. 48; Hay, 1889, p. 602; Hay, 1892, p. 409 (*Ambystoma tigrinum*); Hoy, 1871, p. 578 (*Amblystoma lurida*); Kumpf, 1934, p. 7 (*Ambystoma tigrinum*); Smith, 1911, p. 16; Surface, 1913, p. 90 (*Amblystoma tigrinum*).

Distribution in New York. Allen, 1869, p, 201 (*Amblystoma tigrinum*); Bishop, 1923, p. 65 (*Ambystoma tigrinum*); Britcher, 1903, p. 120 (*Amblystoma tigrinum*); Cope, 1867, p. 184; Cope, 1889, p. 84; Davis, 1928, p. 121 (*Ambystoma tigrinum*); DeKay, 1842, p. 83 (*Triton tigrinus*); Ditmars, 1905, p. 167 (*Amblystoma tigrinum*); Eckel and Paulmier, 1902, p. 399; Eights, 1836, p. 132 (*Salamandra tigrina*); Engelhardt, 1916, p. 20 (*Amblystoma tigrinum*); Engelhardt, 1916*a*, p. 32; Engelhardt, 1916*b*, p. 48; Fowler and Dunn, 1917, p. 8 (*Ambystoma tigrinum*); Kumpf, 1934, p. 7, Noble, 1927, p. 2; Sherwood, 1895, p. 28 (*Amblystoma tigrinum*); Wilmott, 1933, p. 184 (*Ambystoma tigrinum*).

HEMIDACTYLIUM SCUTATUM (Schlegel)

(*Salamandra scutata,* Fauna Japonica, Saur. Batr., 1838, p. 119)

Four-toed Salamander

Figures 3*a–b*, 4*j*, 35–38

The four-toed salamander is the smallest species found in the State and differs from other members of the family in the North in the possession of but four toes on each foot.

Description

Size. Measurements of 93 adult males and 64 adult females, collected at the same locality at essentially the same time of year, have been presented by Blanchard and Blanchard (1931, p. 158) and give an excellent idea of the size attained by the four-toed salamander at Hamburg, Mich. These figures may be taken as probably fairly representative of the species throughout the northern part of its range.

The males were found to vary in length from 49.8 to 76.6 mm with the average 65.12 mm. Females varied from 62 to 87.7 mm and averaged 74.72 mm. When the total lengths of adult males were plotted by 2 mm class intervals they formed a polygon with a distinct mode at about 66 mm and a lesser prominence at about 58 to 60 mm. These figures were interpreted as indicating that in southern Michigan sexual maturity is ordinarily attained at the end of the third season and that individuals of this age were represented in the polygon by the prominence at 58–60 mm. The mode at 66 mm was assumed to represent males in their fourth or later season.

In another collection, reported by Blanchard and Blanchard (1932, p. 159) 83 males varied in length from 60.2 to 87.9 mm and averaged 73.98 mm. The 41 females averaged 83.66 mm with extremes of 69.7 and 94.7 mm. It is here apparent that the females were about 9.6 mm longer than the males.

The tail of the male is relatively a little longer than in the female. Measurements of a total of 171 adult males from two Michigan localities indicate that when tail length is divided by body length the variation is from 1.05 to 1.84. In a series of 106 females from the same localities, the variation is from 1.03 to 1.60. The averages are from 1.28 in the females to 1.49 in the males (*ibid.*, p. 158–60).

In adult females from the vicinity of Ithaca and Albany, N. Y., collected in May, October and November, varied in length from 60 to 83 mm and averaged 70.85 mm. The few males I have taken vary from 49 to 73 mm and average 60.2 mm.

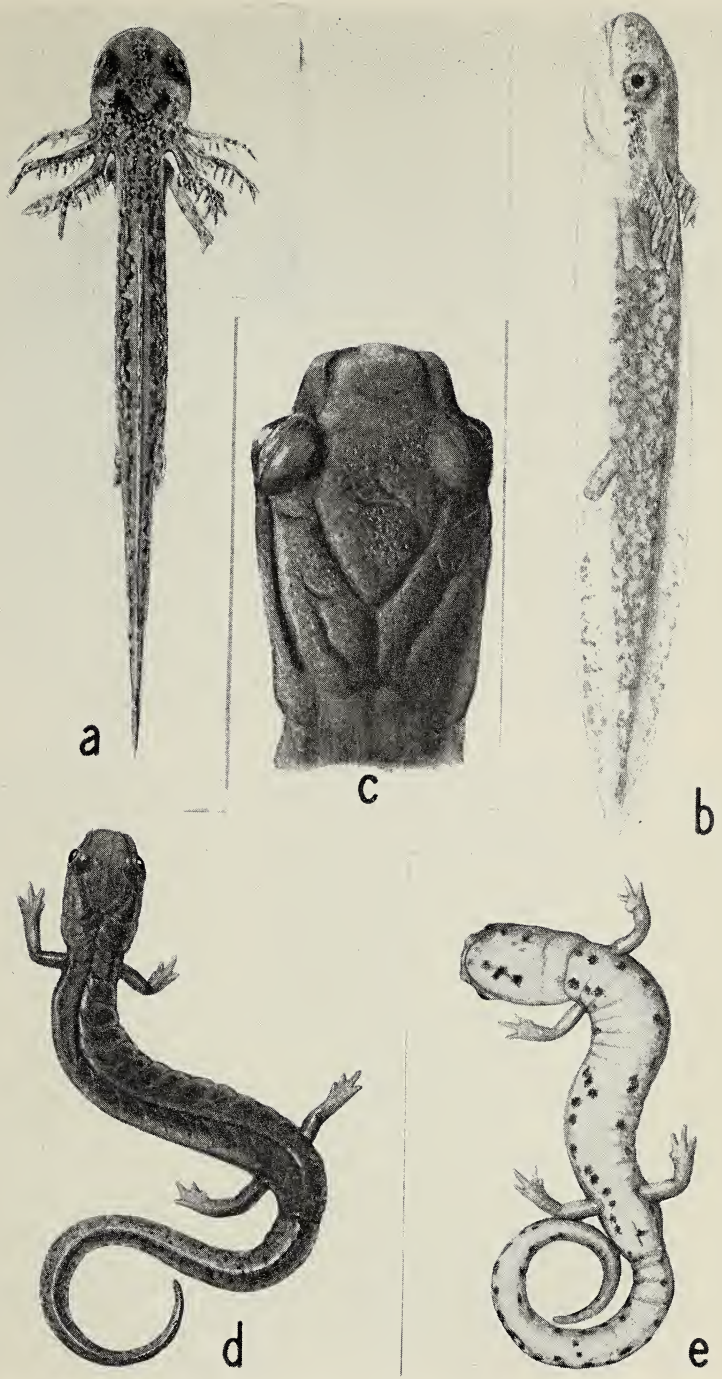


Fig. 35 *Hemidactylium scutatum.* a. Larva at hatching, X 8, New Salem, N. Y., May 22, 1924. b. Same, side view to show dorsal keel. c. Head of male enlarged. White Oak, Ingham Co., Mich. E. K. O'B., del. d. Adult male, dorsal view, X 2. Ringwood, Tompkins Co., N. Y. Sept. 10, 1933. e. Same, ventral view, H. P. C., del.

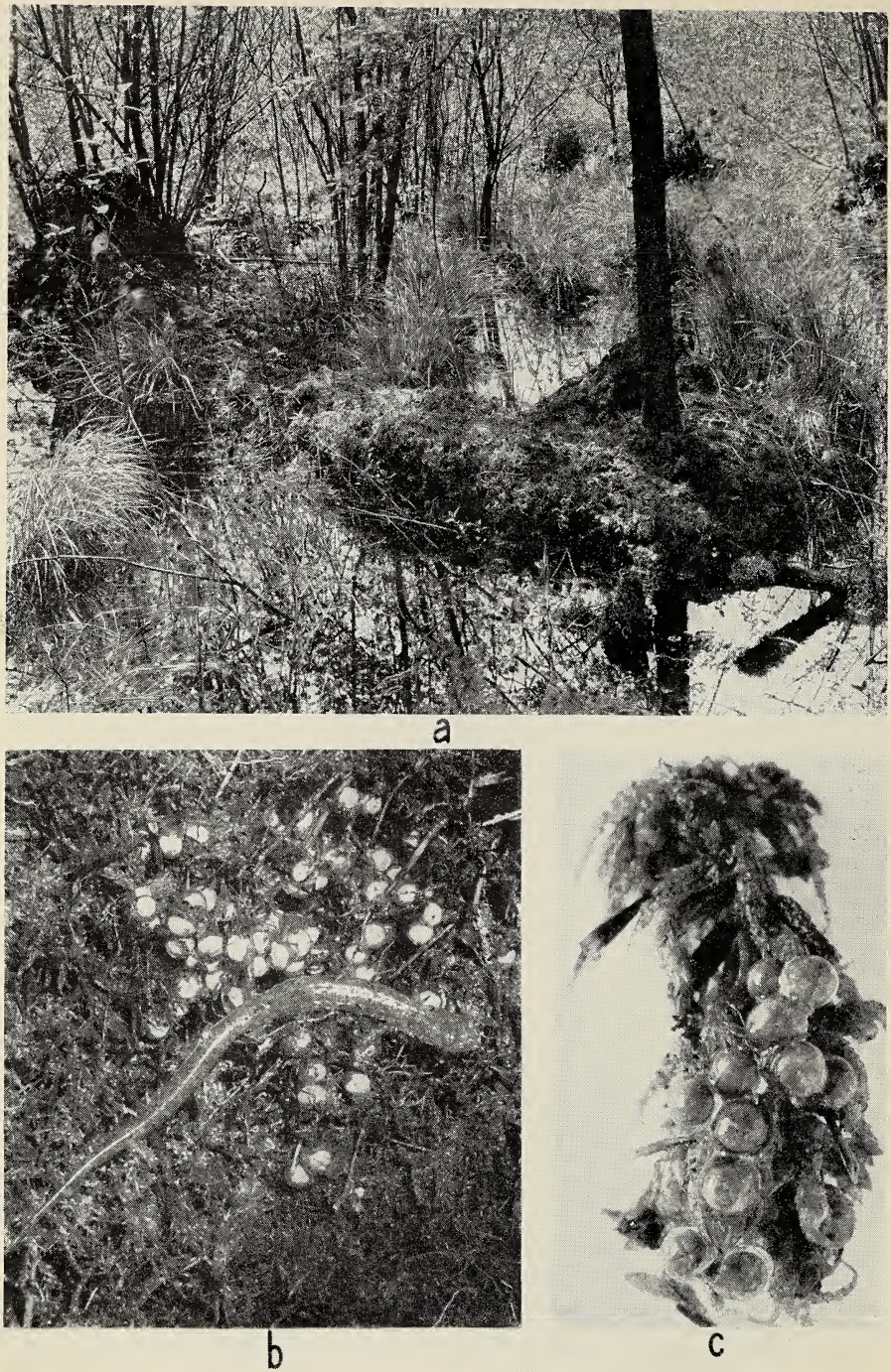


Fig. 36 a. A typical egg-laying place for *Hemidactylium scutatum* in New York. Swamp at New Salem, N. Y., May 18, 1923. The moss-grown log in the middle ground is every year occupied by several females that deposit their eggs just above the water. b. The female and her eggs. A bit of the moss turned back at the water's edge to expose the eggs. May 18, 1923. c. A cluster of eggs in early segmentation stages. New Salem, N. Y., April 27, 1923. E. J. S., photo.

Form. The head of the female is broad and flat with the snout bluntly rounded and the sides nearly parallel. The eyes are prominent and strongly retractile. The trunk is nearly cylindrical and comparatively short. The tail is slightly longer than the head and trunk, oval in section at the base, somewhat swollen about midway of its length and weakly keeled above and below on the distal half. At the base of the tail there is a constriction marked by two impressed lines which mark the point of detachment in autotomy. The less prominent anterior line indicates the point of separation of muscles and vertebrae, the deeper constriction behind it the line of separation of the skin. The legs are slender but strong, the toes four with the inner and outer rudimentary.

A distinct median dorsal impressed line originates near the base of the tail and extends onto the head where it bifurcates and sends a branch to each eye. There are thirteen or fourteen costal grooves which are continued on the back and meet the dorsal groove at an acute angle. The gular fold is well developed and extends on the sides of the neck where it meets a longitudinal groove running to the eye.

The entire surface of the body has a finely pitted or granular appearance.

The tongue is rather small, narrow and bluntly rounded in front and behind. It is attached medially in front, with the lateral margin and posterior third free. The teeth are quite variable in number and arrangement. The vomerine teeth in the males are usually in a single regular row. In some, however, these teeth may be enlarged and form a broken and irregular line. They are usually separated from the parasphenoids (in 7 of 11 examples); in two young specimens and one large adult they are continuous and in one specimen separated from the parasphenoids on one side and continuous with them on the other. The teeth on the premaxillae are enlarged in the male and usually three or four in number. In some instances they perforate the upper lip and are visible when the mouth is closed. In most cases, however, they merely lie against the upper lip and force it forward.

In the female, there is no conspicuous enlargement of the teeth on the premaxillae and the vomerine teeth are usually in two or three rows sometimes regularly spaced but more often irregular and scattered. The vomerine and parasphenoid teeth are usually separated but in a few individuals they form a continuous series. In no instances have females been noted with the vomerine teeth enlarged or forming single continuous series.

The males are more slender than the females and average shorter. Other differences are noted under the color description and the account of sexual dimorphism.

Color. Males and females differ somewhat in color and descriptions are given of typical examples of each sex.

In a living female 75 mm long the head and trunk above is bright reddish brown fading slightly on the upper sides and becoming distinctly grayish on the lower sides between the costal grooves. The upper surface of the legs and tail has a ground color of reddish orange blotched with brown. The snout is bronzy and on each side above the shoulders there is a small, elongate, light reddish patch. Small flecks of red appear in the extensions of the costal grooves on the back. The venter is bluish white with irregular flecks of black most abundantly distributed along the sides. The center line of the tail is free from spots and that of the belly nearly so.

A mature male 54 mm long has a median band extending the entire length of the body, widening on the head and narrowing on the tail. On the trunk the ground color of the band is light brown with a pale bluish overcast. On the top of the head and on the tail, beginning at the constriction that marks the point of detachment in autotomy, the color is reddish brown with tinges of orange. The snout, the upper joints of the legs and a spot above each shoulder are bronzy. Through the center of the dorsal band there is an irregular broken line of small dark spots and on each side of this median line a few scattered spots. Bordering the broad median band, the upper sides are rather heavily pigmented with black and small, scattered, bluish white flecks. On the lower half of the sides and on the tail the light flecks predominate. The venter is white, very lightly tinged with bluish and marked with small, irregular black spots except along the midventral line of the tail and midline of the belly. On some individuals the black spots of the venter tend to fuse and form broken lines; or they encroach on the middle line of the belly. The pigment of the lower surface of the legs is yellowish or reddish rather than black and the white of the belly sometimes continues down the under side of the legs almost to the toes.

Sexual differences. The mature male is distinguished from the female by its smaller average size, more slender form, relatively longer tail, and to some extent, by its color. Other striking differences are to be found in the shape of the snout which in the

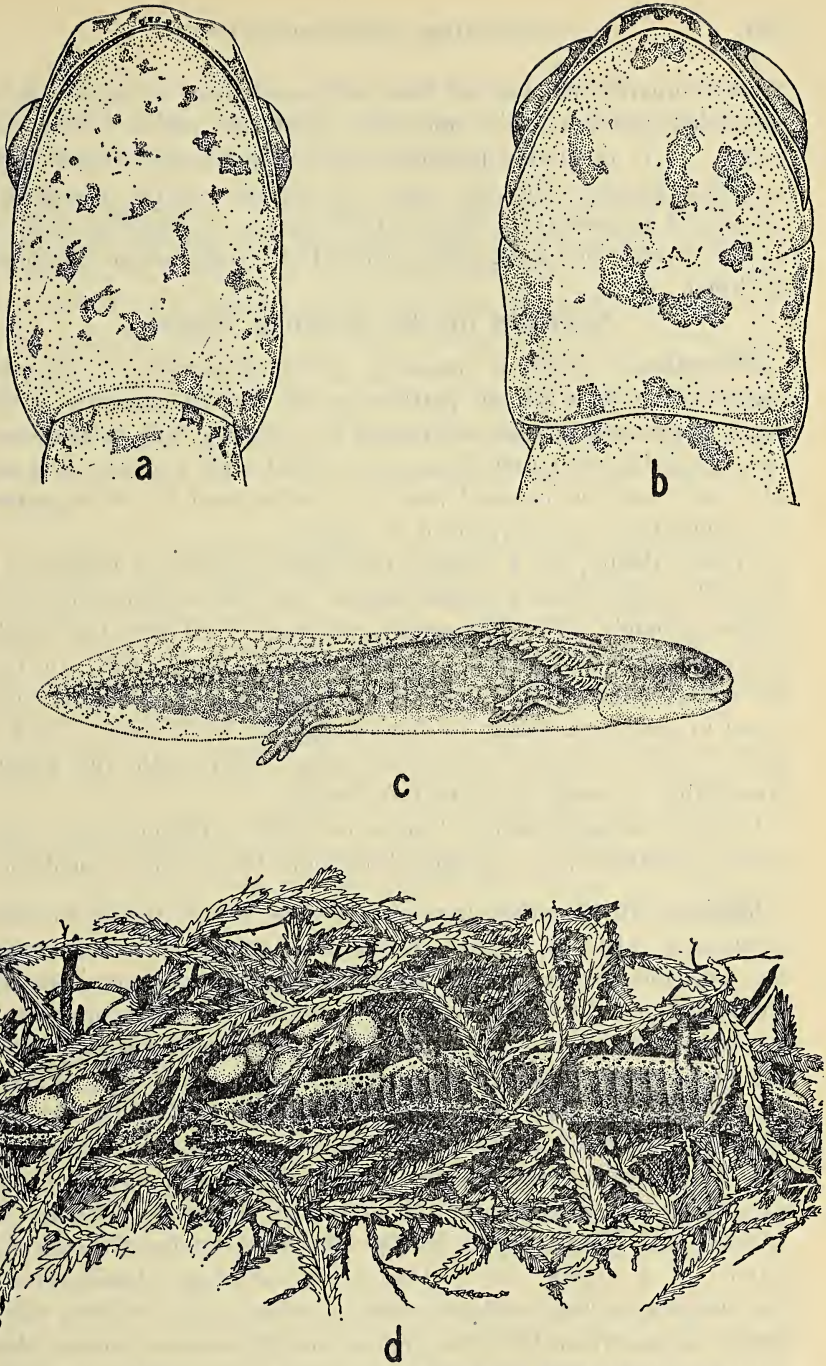


Fig. 37 *Hemidactylium scutatum*. a. Under side of head of male to show the truncated snout and teeth perforating lip. b. Under side of head of female to show rounded contour of snout. c. Full-grown larva. Michigan, July 18, 1932. Actual length 18 mm. H. E. R., del. d. Female depositing eggs in moss. New Salem, N. Y., May 11, 1923. H. E. R., del.

male is squarely truncate in front and swollen in the region of the naso-labial grooves. The upper lip is sinuous and overhangs the lower. It is otherwise peculiar in the development of the teeth, as noted above. The few that are present on the premaxillae are placed somewhat in advance of those on the maxillae and one or two on each side are greatly enlarged and visible when the mouth is closed.

Activities of the Breeding Season

Migration. There is an early spring migration of the adult females from their winter quarters to the nesting grounds. Adult males apparently do not undertake the journey but on one occasion two half-grown individuals were found with a female at a nest site and it may be assumed that they participated in the migration. The migrations are performed at night.

In the Albany, N. Y. region the earliest record of migration is April 8, 1925, when a single female was found approaching the nesting grounds. The first eggs were found April 13th but females continued to arrive at the nest site through April 15th. In 1923 and 1924, females were not encountered in migration but were found in their nests ready to deposit eggs on April 26th. The first eggs in each of these years were found April 27th, the females presumably arriving a short time before.

In every instance where I have observed a female at her nest, she has remained with her eggs throughout the period of incubation.

Mating. In an earlier account of the life history of the four-toed salamander (Bishop, 1919) I indicated that the mating season was probably in the spring, rashly basing my judgment on the reports of the discovery of males and females found together at this season of the year. It is now well established that there is an extended mating season, through late summer and fall, evidence for this having been presented by Dieckmann (1927*a*, p. 284) who sectioned the spermatheca of a 77 mm female killed in August and found it filled with sperm, and by Blanchard (1933, p. 40) who found and reported for the first time, the spermatophores.

Noble and Brady (1930, p. 53) described briefly the courtship pattern of a number of Plethodontids including *Hemidactylium*. The maneuvers were said to consist of a series of, "rubbing movements during which the male applies his lips, cheeks, mental gland (in those species that have one) or side of body to the snout of the female. This arouses the female's interest in the male. In the second phase of the courtship, the female follows the male, keeping

her chin pressed closely against his tail base as they move about the tank. The male, especially when he is not moving forward, undulates the base of his tail from side to side."

Spermatophores. Adult males and females collected September 29, 1929 by Blanchard (1933, p. 40) were confined together and on the morning of October 1st a spermatophore was found on the surface of a leaf. Its base was an expanded gelatinous disk, about 2 mm broad, tapering upward into a stalk about 1 mm in diameter and ending in a pale yellowish top containing sperm. The whole was only 2 mm high. Other spermatophores were found varying somewhat in size but agreeing in general characteristics. They were found as early as September 15 (1930) and as late as October 25 (1929).

The nests of Hemidactylium. The nests of the four-toed salamander are often simple little cavities in the sphagnum moss or among moss rhizoids and grass roots. They are invariably placed in the vicinity of water and usually immediately above it. The many nests I have examined have all been buried three or four inches in the moss and within six inches of the water.

The nest cavity often has the appearance of being formed by turning movements of the female but in some instances it is evident the female merely takes advantage of a natural opening in the moss or some hollow between the roots of a bog plant. In New York State I have never found a nest of this species that was not in sphagnum moss. Blanchard (*ibid.*, p. 2), however, reported finding the eggs, "either just under the moss covering of an old stump or root or entangled in moss rhizoids and grass roots, not in the earth below the roots nor in the moss and grass above the roots." He predicted (p. 3) that eggs would doubtless be found in sphagnum moss in Michigan and subsequently (1928, p. 44) recorded them in such a situation from the Douglas lake region. Blanchard (*ibid.*, p. 3) also reported eggs in numbers, "attached to the sides of crevices and hollows in the soft rotted wood of a large water-soaked log that projected thirty feet or so out into the pond, and in one instance eggs were found under the loose bark of an old stump that stood at the edge of the water."

The nests are usually placed at the margin of a pond or along the sides of a moss-covered log projecting into the water, but on several occasions I have found them some distance from shore, on little islets which, it was apparent, the female must have reached by swimming.

The nests may be found at the water's edge in fairly open bogs, by deeply shaded woodland pools and along the slow watercourses that meander through swamps.

When disturbed at the nest the female sometimes seeks to escape by burrowing. On one occasion, however, a female took to the water and hid herself among the leaves at the bottom. A few minutes later she returned to her nest and again coiled about her eggs.

The egg-laying process. On two occasions I have observed the deposition of eggs under natural conditions in the field. On April 28, 1924, in a swamp near New Salem, N. Y., two females were found in the act of depositing eggs. The females were discovered by gently turning back the loose moss that hung from the side of a log projecting out into the water. They occupied little openings in the moss and were resting upside down grasping rootlets and bits of moss with the feet while slowly forcing the eggs out, one at a time. The observations were made at noon.

On April 13, 1925, at the same locality, a single bob-tailed female was found depositing her eggs at 3 o'clock in the afternoon. A second female occupied a definite cavity near-by but had not yet started the egg laying.

The habit of turning upside down when depositing the eggs is characteristic of a considerable number of species that lay their eggs in water, and attach them to the lower surface of some support. It is obviously the method employed by the mudpuppy, *Necturus,* the two-lined salamander, *Eurycea b. bislineata,* the red salamander, *Pseudotriton ruber* and *Gyrinophilus porphyriticus* and *G. danielsi. Steriochilus marginatum* has been reported by Noble and Richards (1932, p. 3) as assuming the same position when laying eggs among water weeds. Even among the terrestrial plethodonts such as *Plethodon cinereus* and *Desmognathus o. ochrophaeus* this method has been employed, and perhaps serves the useful function of keeping the eggs together where they can be better guarded by the parent. In the case of the four-toed salamander, however, particularly when the eggs are laid in sphagnum moss, it is difficult to find any advantage this method offers. The female tucks her eggs among the strands of moss in such a way it is often difficult for her to cover or surround them. Perhaps the habit was acquired when the eggs were laid under different circumstances, and continued after its usefulness had departed.

Humphrey (1928, p. 308) has watched the deposition of eggs in the laboratory and his account agrees in most details with my own observations. Humphrey, however, recognized only one egg envelop in addition to the vitelline membrane, while in all my fresh material

and some preserved, two are clearly shown. Several minutes were consumed in the laying of a single egg and the whole complement probably requires several hours for its deposition.

The time of egg laying varies somewhat from year to year and at different localities. The following table summarizes some records from New Salem, N. Y., and the McLean bogs.

New Salem	April 27, 1923	Early segmentation, probably laid April 26.
New Salem	April 28, 1924	Two lots in early segmentation stage; two females depositing eggs.
New Salem	April 13, 1925	One female depositing eggs; a gravid female in moss.
New Salem	April 27, 1926	Fresh eggs.
McLean	May 14, 1919	Early embryo; probably deposited several days before.
McLean	May 11, 1923	Females just starting to lay (Humphrey, 1928, p. 307).
McLean	May 2, 1934	One gravid female; deposited 34 eggs May 3; one female with 36 eggs in early segmentation stages.

Blanchard (1934*a*) has indicated that, in southern Michigan, the time at which the first eggs of *Hemidactylium* may be expected is definitely the middle of April.

The egg mass. The eggs are deposited in a mass and cling together and to the surrounding materials of the nest cavity by their sticky outer envelops. When eggs are in contact with one another, the outer envelops fuse and seem to form a common covering; actually they maintain their integrity and may be separated.

I have counted the eggs in a considerable number of masses and found them to vary in number from 22 to 64. The average in New York is about 50. Often several females will select the same nest site and place their eggs so close together it is impossible to confine each female to her own. On one occasion four females occupied a small area in the side of a sphagnum clump and deposited a total of 204 eggs.

Development

The egg and its envelops. The egg itself has a diameter of from 2.5 to 3 mm and is very lightly pigmented above. The lower side is yellowish, deriving its color from the yolk. There are two definite envelops present in addition to the vitelline membrane, the outer one having a diameter to 5.5 mm, the inner one about 4 mm. The outer envelop is relatively thin, but tough, elastic and sticky. It is quite irregular in thickness and tends to spread out somewhat when in contact with other eggs or bits of moss or roots. The inner

layer forms a thicker envelop which is rather fluid in its consistency, like clear thin jelly. In some eggs preserved in alcohol for several years, the separate layers of jelly seemed to have fused and were indistinguishable.

The incubation period. In individuals reared in the laboratory approximately 30 days were required for development (Bishop, 1919, p. 265); Blanchard (1923, p. 264) estimated the normal time of hatching in the field to be approximately 38 days in the Ann Arbor region. While the extent of the period of incubation is somewhat variable, depending on temperature, moisture and perhaps other factors, definite records of egg-laying and hatching in the field are now available and extend the length of the period to a total of 52–60 days.

On April 28, 1924, two females were observed, in the field, in the act of depositing eggs. The nests were marked for future identification and left undisturbed, except that a few eggs were removed to the laboratory for study. The eggs left in the nests hatched June 19th-20th, after an incubation period of 52–53 days. Those removed to the laboratory hatched May 20th–23d or in 22 to 25 days after laying.

On April 13, 1925, a bob-tailed female was discovered in the act of depositing her eggs and the nest marked for study. It was examined at intervals during the succeeding weeks and on each occasion the same female, recognizable because of her mutilation, was found in attendance. On June 13th the eggs seemed ready to hatch and were still guarded by the female. On June 15th the female and her brood had departed.

Blanchard's estimate of 38 days for the normal time of hatching in the field is, in this instance, extended to 62 days and my own record of 30 days for development under laboratory conditions is supplemented by others in which the period was shortened to 22–25 days.

Usually there is an interval of several days between the first appearance of the species and the deposition of eggs. In the three-year period, 1924–26, at New Salem, N. Y., the dates were as follows:

FIRST APPEARANCE	EGGS	HATCHED	INCUBATION PERIOD
April 15.....	April 28.....	June 19–20...	52–53 days
April 8.....	April 13.....	June 14.....	62 days
April 21.....	April 27.....	.....	.....

The newly hatched larva. Larvae at hatching average 12.4 mm and vary from 11 to 14 mm.

The head is broad, smoothly rounded on the sides, widest at a point midway between the eyes and gills and then tapering to the bluntly pointed snout. The body and tail are strongly compressed and from above, wedge-shaped. The eyes are prominent with the pupil black and the iris greenish yellow. The fore legs are well developed and in some individuals have four toes. A few specimens have only two toes well indicated. The hind limbs are short and directed backward. On some, four toes are indicated but other individuals have only two or merely a blunt lobe without evidence of toes. The gills are slender, tinged with orange at the base, pigmented with black, and provided with two rows of flattened filaments; their length is about equal to one-third the distance between the fore and hind legs. The tail comprises about two-fifths of the total length. The tail is keeled above and a dorsal fin continues along the midline of the back nearly to the head, a development unique among the larvae of plethodontids. The ventral keel extends to the base of the tail. The rudimentary condition of the hind limbs at hatching, which is characteristic of larvae of several other families, is found in the Plethodontidae only in *Hemidactylium* and possibly in *Pseudotriton ruber*.

In comparing series of specimens hatched under laboratory conditions with those taken in the field, considerable differences are evident in the degree of development of the legs, toes and gills. Laboratory specimens sometimes hatch in a more advanced condition with the toes indicated on the hind legs and fully developed on the fore. When specimens are permitted to remain in the nest until the time of hatching, though the period is much longer, often the hind legs show the toes in a more rudimentary condition.

The head of the larva is tinged with orange, green and yellow and marked with dark brown or black pigment spots. The dark spots are fairly uniformly distributed in larvae prematurely hatched but in specimens hatched in the field they are concentrated in a broad Y-shaped mark on the back of the head and to a less extent in a short band extending from the open end of the Y nearly to the end of the snout. On the side of the head, there is a short, wide band of dark pigment extending from the eyes to the gills. Along the midline of the trunk there is a light band with irregular edges obviously formed by the coalescence of the two rows of light spots which formed an alternating series in younger larvae. Bordering the light dorsal band, the pigment is concentrated to form narrow, dark, worm-like markings. The sides of the trunk to the level of the legs, are marked with a reticulated pattern of brown and black

pigment on a light, greenish yellow ground. The light middorsal band and the reticulated pattern of the sides are continued on the tail to its tip but these markings do not invade the fins. The tail fins are simply blotched with scattered brown chromatophores most abundant near the margins.

Length of the larval period. I have never succeeded in collecting fully developed larvae in the field. Blanchard, however, (1923, p. 267) has taken a considerable number and has estimated that the larval period has an extent of about six weeks.

Larvae on hatching wriggle their way actively through the moss to the water below. Blanchard (*ibid.*, p. 264) observed the hatching in the field on May 27th and later, through June, collected larvae in the ponds. On July 2d a single individual was collected which had a noticeably reduced tail and sometime between this date and July 30th (Blanchard estimated about July 15th) the transformation took place.

It is likely that there is considerable variation in the extent of the larval period, depending somewhat on conditions in the ponds—temperature, early drying or other factors. I have kept larvae hatched May 27th until October 3d without the slightest evidence of gill reduction, a period of over 18 weeks.

Mature larvae. Fully grown larvae average about 20 mm but may vary from 18 to 24 mm, judging by the measurements of recently transformed individuals collected by Blanchard.

Through the kindness of Dr F. N. Blanchard I have received some larvae, three individuals collected July 10, 1932, and two about full-grown taken July 18, 1932, in Michigan. The three smaller specimens measure 15.5, 15.7 and 17 mm respectively and the larger of the two taken July 18th is 19.5 mm.

In the fully grown larva the head is rather strongly convex and the snout, from the side, very blunt. The gills are progressively longer posteriorly, the third twice as long as the first and about equal to the distance between the end of the snout and the base of the gill.

The legs are well developed and the toes fully differentiated, the inner one rudimentary. The dorsal keel extends forward to the sixth costal groove, counting from the axilla, and from that point forward as a low ridge almost to the head. In younger larvae the fin extends as far forward as the second costal groove.

The head is rather uniformly pigmented above except for a darker Y-shaped mark which sends its branches forward to the eyes, and small light areas in the region of the naso-labial grooves. On the

trunk there is a slight indication of the early larval pattern in the median light band which narrowly borders the back fin. This light band becomes quite prominent on the tail where it fades into the upper keel. There is a dark bar on the side of the head extending through the eye. The sides of the trunk and tail are well pigmented to the level of the legs where the color ends abruptly. Small light spots are irregularly scattered on the sides of the trunk and on the tail tend to form two, or sometimes three, irregular lines. The gills, dorsal surface of the legs and toes are well pigmented and spotted with the lighter marks. The tail fin above has a reticulated pattern but the lower fin has only a few scattered chromatophores. The larva is unique among plethodontids in its possession of a dorsal fin on the trunk.

Transformation. The recently transformed individuals are characterized (Blanchard, 1923, p. 267) by their conspicuously short tails which are practically without constrictions, by the black patch on each side of the head marking the closure of the gill slits and by the horizontal dark bar through the eye. A specimen taken July 2d with fully developed gills but otherwise giving evidence of approaching transformation, measured 17.8 mm. Five fully transformed individuals collected July 30th varied in length from 18.5 mm to 25 mm.

Development to maturity. Measurements of a splendid series of 352 specimens collected October 10 and 12, 1924, by the Blanchards in Hamburg township, Mich., has made possible the determination of age groups with a considerable degree of accuracy. These specimens together with others from different localities and some from the same locality taken in April have been used by Blanchard and Blanchard (1931, p. 150) in the preparation of graphs which indicate the characteristics of the age groups as follows: The young of the year in October and November vary in length from 19.9 to 41.6 mm in females and from 22.1 to 38.3 mm in the males. The averages of the groups considered were from 30 to 33 mm.

The young of the year are characterized by the short tail which is a little less than the length of the body.

Individuals composing the group intermediate between the young of the year and the adults, and judged to be at the end of their second season, gave measurements as follows: males varied in length from 45.3 to 56.8 mm and averaged 50.64 mm; females averaged a little longer, 55.14 mm and varied from 45.5 to 66.9 mm. The tail is relatively longer in individuals in their second season than in the

young of the year and varies from 1.00 to 1.37 of the total length. The constriction at the base of the tail is well developed at this age.

Sexual maturity is apparently attained when near the end of the third season, at an age of approximately two and one-third years. Measurements of adults of both sexes have been given under the paragraph dealing with size.

Habits

The four-toed salamander is an inconspicuous little creature and because of its small size and retiring habits is seldom observed except by the initiated. During the warmer months, most of the daylight hours are spent in hiding beneath some object on the surface of the ground and when cold weather puts a limit to its activities, it may be found beneath surface materials or rather deeply buried. At night, particularly during the migration period in the spring, it becomes active and may be found wandering on the surface and more or less directly proceeding to the nest sites.

The habit of coiling up when exposed or disturbed was observed by Sherwood (1895, p. 30) and independently by A. H. Wright. In fact, this position is frequently assumed by the animal when it is in repose.

The adult four-toed salamander can swim and the female sometimes voluntarily takes to the water when seeking a nest site but the animal is not very well adapted to this medium and will drown if not given the opportunity to crawl out.

The legs of the salamander are small and the animal is not much given to leaping but it can throw itself almost its length by violent contortions of the body and tail.

Perhaps the most striking habit is the voluntary dropping of the tail. The constrictions at the base of the tail mark the point of detachment in autotomy and because the point of separation of muscles and vertebrae is before the place of separation of the skin, the skin is of sufficient length to cover the wound of the stub over which it immediately shrinks. The detached part of the tail wriggles violently for several minutes probably stimulated by the exposed muscles, then gradually comes to a rest. If stimulated by pinching, however, the tail again begins its wriggling and continues for a short time. This is a highly specialized, protective reaction and an elaboration of the method employed by several other members of the family that part with their tails but at no particular point.

Food. No detailed studies of the food of the four-toed salamander have been reported. Hay (1892, p. 44) states, "The

food is said to consist principally of worms and insects." "The stomach of a female taken at Ringwood (near Etna), N. Y., May 20th, contained the larva of one of the Microlepidoptera (Crambinae and probably of the genus *Crambus*) and the remains of some small staphylinids," (Bishop, 1919, p. 256). Surface (1913, p. 93), found a specimen had taken spiders, springtails, drosophilid flies, and homopterous bugs.

Habitat

Early accounts usually recorded this salamander from terrestrial situations. The following resumé is taken from my 1919 report on the species: According to Ditmars (1905, p. 169), "It is strictly terrestrial and inhabits timbered regions, where it hides under logs and stones." By Sherwood (1895, p. 30), it was found in the open woods where grass was growing: "All were under stones and curled. Single specimens taken at Harrington, N. J., from under boards or logs about 5 feet from a pond. Time of captures May and June." W. H. Smith, (1882, p. 722) " . . . found in April under old logs and rails in open woods, at some distance from the water." Ruthven, Thompson and Thompson (1912, p. 34) state that specimens were, "found (May 13, 1901) in earth on the roots of a violet which had been pulled up"; "under loose moss"; "April, 1902, under a log"; "one was just inside the bark of a rotten stump." On Larch hill, near Ithaca, specimens were found under stones and the bases of stumps (Reed and Wright, 1909, p. 402).

Specimens recorded by Moesel from hillsides near Ithaca, "were taken from beneath large, flat stones which were well imbedded and surrounded by a mass of shrubbery." Others were found buried to a depth of six or seven inches.

Britcher (1903, p. 120) was perhaps the first to record specimens from sphagnaceous areas. Wright and Moesel (1919, p. 64) also record specimens from a similar situation.

Since the rediscovery of the eggs in 1918 (Bishop, 1919, p. 258) the investigations of Blanchard (1922, 1923, 1931, 1933, 1934, 1935, 1936) and others (Dieckmann, 1927; Branin, 1935) have thrown additional light on the habits and habitat preferences. Blanchard (1923, p. 268) in his summary of the life history writes:

> Eggs will not be found unless the breeding site is directly adjacent to a piece of wooded land, nor will adults be found in woods not adjacent to a suitable breeding site.

This is quite generally true but exceptions may be noted. The Larch meadows nesting area near Ithaca, N. Y., where many females have been found during the egg-laying season, lies at the base of a

hillside meadow and the nearest woods are far from being "directly adjacent."

A typical habitat in Michigan is described by Blanchard (1922, p. 1) as follows:

Here a small piece of oak woods occupies an uneven ground adjacent to a wet grassland that borders a moderate-sized stream. Partly in and partly outside of the woods lies a small, irregular pond, roughly 300 feet by 30 feet, with low grasses, sedges, and mosses at its edges, and numerous grassy and shrubby clumps forming little islets out from shore. Duckweed, crossed by numerous muskrat swimways, almost entirely covers its surface, beneath which may be seen a plentiful aquatic vegetation with sphagnum in places abundant.

Good-sized oaks nearby admit only an intermittent light during most of the day. Here wood frogs, green frogs, cricket frogs, and newts are abundant. And here in the rhizoids and roots of moss and grass the eggs of *Hemidactylum scutatum* were first found this spring (1922) on May 13.

The situations in which the eggs have been found in Michigan, differ somewhat from those in New York where the egg-laying site is usually in sphagnum moss. The moss may be in deep, shaded situations in mixed forests of hemlock, pine and hardwoods, in open larch meadows or in the sphagnum-heath association bordering bog ponds. In such a bog situation the eggs were first found in New York and I quote the following paragraph from my earlier account (Bishop, 1919, p. 258).

The common woody shrubs are represented by clumps of red-osier dogwood (*Cornus stolonifera*), hoary alder (*Alnus incana*), and an occasional shad brush (*Amelanchier* sp.). A few seedlings of the arrow-wood (*Viburnum dentatum*) and vines of *Clematis virginiana* find root among the larger shrubs. The herbaceous plants consist principally of small groups of meadow rue (*Thalictrum polygamum*), white violet (*Viola blanda*), touch-me-not (*Impatiens biflora*), water pennywort (*Hydrocotyle americana*), and scattered single plants of the cuckoo flower (*Cardamine pratensis*). In the open water spaces between, the marsh marigold (*Caltha palustris*) and other bog-loving forms are scattered. Rank growths of sphagnum and other mosses cover the roots and bases of the shrubs and in these masses of moss the Four-toed salamander lays her eggs.

The circumstances under which hibernating individuals have been found in considerable numbers, have been indicated by Blanchard (1933*a*, p. 216). The article is short and to the point and I give it here in its entirety:

The places where *Hemidactylium,* the four-toed salamander, has been found assembled in late autumn indicate where it spends the winter. On November 5, 1922, eighteen were found in and adjacent

to a single short (six foot) log in a piece of woods in White-oak Township, Ingham County. They were in the cavities of the rotted wood and under leaves close by. In association with them were a number of other amphibians (1 *Plethodon cinereus,* 6 *Ambystoma jeffersonianum,* 1 *A. maculatum,* 4 *Triturus viridescens*) and a garter snake, *Thamnophis sirtalis.* Since only one other specimen of *Hemidactylium* was found on this day, it was very likely more than a coincidence that so many were found together.

It has not been an unusual occurrence in collecting in late autumn to find amphibians concentrated in this way. On another occasion, large numbers of *Hemidactylium* were collected under leaves within an area of a very few square feet. They were associated with great numbers of several other species, the whole group amounting to:

Four-toed salamanders (*Hemidactylium scutatum*)	nearly 200
Spring peepers (*Hyla crucifer*)	114
Swamp tree frogs (*Pseudacris triseriata*)	88
Wood frogs (*Rana cantabrigensis*)	48
Jefferson's salamanders (*Ambystoma jeffersonianum*)	in
Red-backed salamanders (*Plethodon cinereus*)	smaller
Newts (*Triturus viridescens*)	numbers

They were snuggled together in little groups or clumps in small depressions or cavities in the ground under the leaves. This was on November 9, 1924, at Iosco, Livingston County. It was a cold day following some mixed cold and warm weather, and the weather thereafter was mostly cold. It seems a fairly safe inference that these amphibians would have stayed there for the winter. But it can, of course, only be surmised whether all or any would have survived the winter there. Under some possible combinations of weather conditions it is conceivable that all might have perished during the winter.

The latest autumn date for finding *Hemidactylium* was December 1 (1921) when I found two under small pieces of old wood. It was a mild day following much cold weather in November. The only other date later than November 9 on which I have collected *Hemidactylium* was November 16 (1924). This was a very cold day and snow was falling. All but two of 55 individuals collected then were young of the year. Possibly many of this age may not work their way into sufficiently protected situations to survive the winter.

A rather favorite place of this species in late autumn is the system of channels to be uncovered by kicking over a small rotted stump. I have often reached into such places, where the roots of the stump had decayed away, and brought forth several four-toed salamanders.

All of these late autumn collecting experiences have been repeated on other occasions to lesser extents, and have led to the idea that these salamanders often congregate in late autumn in places where they will remain through the winter. Frequently these are channels or crevices in the ground, into which they crawl.

Spring collecting has tended to verify this conclusion. For example, on April 20, 1923, six days before the first eggs were recorded

at that locality (in Pittsfield Township), a dry stick on the oak leaves covering the floor of the woods was kicked aside. One scratch at the leaves where the stick had been, uncovered two or three four-toed salamanders close beside a hole about one inch in diameter. The hole led straight downward about ten inches. Under the leaves directly beside the hole about fifteen individuals of *Hemidactylium* of all sizes were disclosed lying quietly together in groups of three to five or six. A few more were found within two feet, making nineteen in all. Since nearly all of these nineteen individuals had empty stomachs they had probably not been foraging this season. Evidently this group of salamanders had only recently come out of winter quarters, presumably from this hole.

Remarks

In the report on a collection of salamanders taken by Baird at Coxsackie, N. Y. (State Cab. Nat. Hist., 1852, 5:22) is a statement, referring to *Hemidactylium scutatum,* as follows: "The ninth species is now for the first time publicly added to the Fauna of the State." It is probable that Baird was not responsible for this note for he had already recorded the species from New York City in 1850, in his Revision of the North American Tailed-Batrachia.

The eggs were first mentioned by Hughes (1886, p. 40), who reported them, "in moss at the roots of trees that stood near ponds," near Brookville, Indiana. They were next found by Bishop (1919, p. 258) who carried them through their development stages and described and figured the eggs and larvae for the first time. Blanchard (1922, p. 2) reported the eggs from Washtenaw county, Michigan, and later (1923, p. 268) and (1931), gave additional details covering the life history, habits, larval period and size groups. In 1933 Blanchard described the spermatophore. Humphrey (1928, p. 308) observed ovulation under laboratory conditions and gave an account of the external features of cleavage and gastrulation.

The relationships of *Hemidactylium* are quite obviously with *Plethodon* from which it differs in the possession of but four toes, marked sexual dimorphism and the basal constriction of the tail. As indicated in an earlier paragraph, the larva possesses a dorsal fin and has an aquatic stage of several weeks' duration. If this larval condition is primitive, as has been suggested, the implication is that its ancestors were aquatic or at least returned to the water for the egg-laying period. Noble (1931, p. 59), however, thinks it more likely, "that the aquatic period in the life of *Hemidactylium* is a derived condition induced by the reduction and early absorption of the yolk in the embryos."

It is true that there has been considerable reduction of the yolk and it is absorbed earlier in embryonic life than in either *Plethodon* or *Desmognathus,* as I first pointed out in 1919 (Bishop, 1919, p. 263), but it requires considerable stretch of the imagination to invoke early absorption of the yolk in the embryo as the reason for the migration of the adult female to the vicinity of ponds for the egg laying, that the larva may have an aquatic period in its life history. Noble, however, has not hesitated to make the suggestion. Dunn (1926, p. 202) discussing the resemblance of the larva of *Hemidactylium* to that of Ambystomidae and Pleurodelidae remarks, "This resemblance is due to the fact that all three have larvae which live in still water. The condition is primitive in the case of Ambystoma and Triturus, but obviously secondary in the case of any Plethodont, and the resemblance is convergence and looks very much like a case of reversed evolution, the larva of the specialized *Hemidactylium* taking on the characters of the larvae of forms much more primitive than any of its immediate ancestors."

It is reasonable to suppose that the resemblance of the body form of the larva of *Hemidactylium* to that of *Ambystoma* and *Triturus* is due to the selection of the same type of quiet water habitat, as Dunn has indicated, but not, of necessity, acquired secondarily, and to derive *Hemidactylium* from *Plethodon* directly, as Noble insists (1927, p. 57), requires one to believe that the four-toed salamander, recognizes the deficiency of yolk in her eggs and to make amends, places her eggs where her poorly endowed larvae can wriggle into the water with the least possible effort.

Although recognizing its close affinity to *Plethodon,* I would not derive *Hemidactylium* directly from it. The evidence seems rather to point toward a divergence from plethodontid stock at a time when the species were more aquatic, at least in their egg-laying habits, *Plethodon* becoming more terrestrial and *Hemidactylium* becoming terrestrial and structurally highly specialized as an adult but retaining the primitive larval condition and egg-laying habits. Some evidence in support of this view is to be found in the suggestion of Blanchard (1934, p. 50) that in as much as the female enters the water voluntarily, in some instances, in seeking a nesting site, the habit may be a primitive one having phylogenetic significance.

Range

"Massachusetts, southern Canada westward to Michigan, south to Georgia and the Gulf States, also Arkansas and Illinois." (Stejneger and Barbour, 1939, p. 17.)

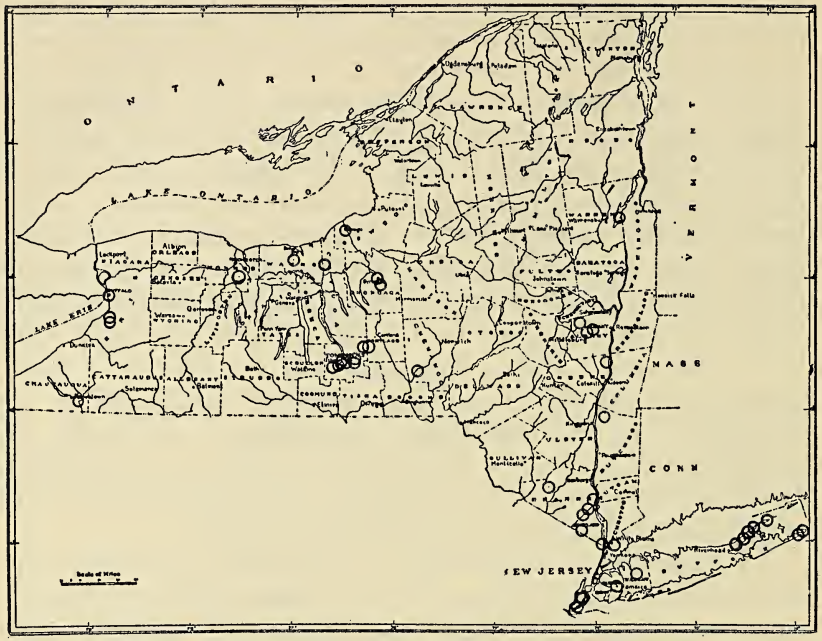


Fig. 38 New York localities for *Hemidactylium scutatum.*

Distribution in New York

General. General throughout the State in suitable situations.

Specific records. ALBANY: *Altamont,* Oct. 12, 1906, 3 spec., N. Y. S. M. No. 87, 87a, 87b (Bishop, 1919); *New Salem swamp,* May 11, 1923, 2♀; Apr. 15, 1924, 3♀ (S. C. B. and W. J. S.); Apr. 28, 1924, ads. and eggs; May 4, eggs; Apr. 8, 1925, 1♀ (S. C. B. and W. J. S.); Apr. 13, 1925, 2♀; Apr. 23, 1925, 1♀; June 11, 1925, eggs; Apr. 21, 1926, 1♀ (S. C. B. and W. J. S.); Apr. 27, 1926, eggs; Apr. 29, 1926, 3♀ and eggs; May 15, 1927, 1♀ and eggs (S. C. B. and B. S. Bronson); *Voorheesville,* Nov. 4, 1922, 2♀, N. Y. S. M. No. 9376–9377. CAYUGA: *Duck Lake bogs,* June 11, 1916 (Wright and Moesel, 1919). CHAUTAUQUA: *Poland Center,* July 8, 1937, 1 ad., Sept. 12, 1937, 1 ad.; Oct. 24, 1937, 1 juv. CHENANGO: *Greene,* May 4, 1928, 1♀, N. Y. S. M. No. 4718 (W. Bartlett). CORTLAND: *Chicago bogs,* May 2, 1934, 1 juv. DUTCHESS: *Red Hook,* July 23, 1938 (Van Auken). ERIE: *Buffalo* (Wright and Moesel, 1919); near Buffalo, Aug., 2♀ (Dieckmann, 1927*a*); *Hamburg,* Apr. 7, 1909, C. U. (Wright, 1918); June 26, 1910, C. U.; *Hampton brook,* Aug. 12, 1925, 3 spec. (R. R. Humphrey). GREENE: *Coxsackie,* 1851 (5th Ann. Rep't State Cab. Nat. Hist., 1852). MONROE: *Mendon Ponds Park,* Apr. 9, 1939, many ♂, ♀ and juv. (Van Auken, Daugherty and Cooper). NASSAU: *Westbury,* June 1916, C. U. ONONDAGA: swamp on *Jamesville road,* 1903 (Britcher, 1903); near *Syracuse* 1 ad., A. M. N. H. No. 2169 (Britcher). ORANGE: *Highland Falls,* Oct. 1896, (Mearns, 1898); *Middletown,* 1 spec. (W. T. Davis); *Palisades Interstate Park,* July–Aug. 1923, 4 ads. (Myers, 1930). OSWEGO: near *Oswego* (Wright and Moesel, 1919). QUEENS: *Jamaica,* May 26, 1912, A. M. N. H. No. 3024 (Boyle, 1914). RICHMOND: *Staten Island,* 1882, 1 ad. (W. T. Davis); near *Moravian cemetery,* (Davis, 1903, Proc. Nat. Sci. Assn. Staten Id. 9(2): 4; 1905 (Proc. Nat. Sci. Assn.

Staten Island, 1905); *Annadale,* Apr. 4, 1909, 1 spec. (J. Chapin); (Wilmott, 1933). ROCKLAND: along *Palisades* and *Hudson river,* 1905 (Ditmars); *Suffern* (Davis, 1908). SUFFOLK: *Calverton,* July 7, 1932, 1 ad. (R. Latham); *Greenport,* May 17, 1925, 2♀ and eggs, (R. Latham); Apr. 16, 1939, 7 ads. and eggs (R. Latham); *Montauk,* May 11, 1928, 1 ad.♂ (R. Latham); June 24, 1928 (R. Latham); *Orient Point,* May 5, 1911, N. Y. S. M. No. 113 (65 Ann. Rep't N. Y. S. Mus., 1913) (Bishop, 1919); *Reed pond,* June 14, 1931, U. R. No. 1459 (R. Latham). TOMPKINS: near *Cayuga Lake,* hillside overlooking the inlet, Apr. 16, 1914, 2 families (Bishop, 1919); Oct. 9, 1916, 3 spec. (Bishop, 1919); Oct. 29, 1916, 5 spec. (Bishop, 1919); *Ellis hollow,* May 16, 1916, 1 spec., C. U. (Bishop, 1919); *Enfield gorge,* Apr. 6, 1914, 3♀ (Bishop, 1919); *Ithaca,* Nov. 27, 1906, U. S. N. M. No. 39405 (Reed); Oct. 15, 1916, C. U. (A. A. A.); *Larch hill,* Oct. 22, 1905, 21 spec. (Bishop, 1919); May 1915, C. U.; Oct. 9, 1916, C. U.; Oct. 28, 1917, 2 ads. (Bishop, 1919); *Larch meadows,* Mar. 25, 1910, C. U.; Oct. 25, 1914, C. U. (A. H. Wright); Apr. 16, 1915, C. U.; May 3, 1916, C. U.; Apr. 11, 1917, C. U.; Apr. 24, 1923, C. U.; *McLean,* May 14, 1919, N. Y. S. M. No. 8610–8620–½ (Bishop, 1919); May 27, 1919 (Bishop, 1919); May 30, 1919, N. Y. S. M. No. 8621–25 (Bishop, 1919); 1922–25, ads. and eggs (Leffingwell, 1926); May 24, 1922, 2 ads. and eggs (F. Harper); May 1, 1923, 1♀ and eggs (Humphrey, 1928); Apr. 20, 1924 (A. H. Wright); May 17, 1924, several ads. and eggs (F. Harper); Apr. 29, 1930, U. R. No. 1337 (S. C. B. and C. R. Crosby); June 2, 1931, ad. ♀ with eggs; Apr. 29, 1933, ad. ♀ with eggs; May 2, 1934, 2♀ and eggs; *Ringwood,* May 20, 1919, N. Y. S. M. No. 8626–8627 (H. Dietrich); May 27, 1919, 5 spec., N. Y. S. M. No. 8628–30 (Bishop, 1919); Sept. 10, 1933, 1♂ (H. Jopson); Apr. 30, 1934, 1 juv. (W. J. Koster); *Six Mile creek,* Apr. 1889 (Reed and Wright, 1909); *Sulphur springs,* Apr. 1889, C. U. (H. W. Norris). WARREN: *Lake George,* Elizabeth Island, Aug. 2, 1917, 1 spec., N. Y. S. M. No. 3750 (Bishop, 1919). WAYNE: *Zurich,* Mud pond, May 17, 1931, U. R. No. 1436 (S. C. B. and H. Zorsch. WESTCHESTER: *Silver Lake park,* 1914 (Deckert, 1914).

Records too indefinite to be placed under counties. *New York,* Oct. 20, 1875, ads., A. M. N. H. No. 2602–04 (E. A. Mearns); probably to be found in this State (Eckel and Paulmier, 1902); *Hudson Highlands,* Oct. 1896, 1 spec., (Bishop, 1919); *New York City* (Baird, 1850); *Thousand Islands,* summer 1900, Hobart College.

Condensed Bibliography

Life history and habits. Bishop, 1919, p. 251–82 (*Hemidactylium scutatum*[1]); Blanchard, 1922, p. 1–3; Blanchard, 1923, p. 262–68; Blanchard, 1933, p. 40; Blanchard, 1933*a*, p. 216; Blanchard, 1934, p. 50; Blanchard, 1934*a*, p. 571; Blanchard, 1934*b*, p. 137; Blanchard, 1935, p. 103; Blanchard, 1936, p. 567–73; Blanchard and Blanchard, 1931, p. 149–64; Branin, 1935, p. 172; Dieckmann, 1927, p. 281–85; Dunn, 1926, p. 196–204; Hay, 1892, p. 409; Hughes, 1886, p. 40; Humphrey, 1928, p. 307; Reed and Wright, 1909, p. 402; Surface, 1913, p. 92–93.

Distribution in New York. Baird, 1850, p. 286; Baird, 1852, p. 21; Bishop, 1919, p. 263; Bishop, 1923, p. 66; Boyle, 1914; Britcher, 1903, p. 120; Cope, 1889, p. 132; Davis, 1884, p. 13; Davis, 1903, p. 4; Davis, 1908, p. 48; Deckert, 1914; Ditmars, 1905, p. 169; Dunn, 1918; Humphrey, 1928, p. 307; Leffingwell, 1926, p. 72; Mearns, 1898, p. 323; Myers, 1930, p. 100; Noble, 1927, p. 2; Reed and Wright, 1909, p. 402; Sherwood, 1895, p. 30; Wilmott, 1933, p. 161; Wright and Moesel, 1919, p. 64; 65th Rep't N. Y. State Mus. 1912, p. 101.

General. Eckel and Paulmier, 1902, p. 400; Noble and Richards, 1932, p. 6; Noble, 1927*a*, p. 63; Noble, 1931, p. 69; Ruthven, Thompson and Thompson, 1912, p. 34–36; Smith, 1882, p. 722; Wright, 1918, p. 56.

[1] In all the references cited the name, *Hemidactylium scutatum,* has been employed.

PLETHODON CINEREUS (Green)

(*Salamandra cinerea* Green, Jour. Acad. Nat. Sci. Phila., 1818, 1:356)

Red-backed Salamander, Lead-backed Salamander

Figures *2h*, *4h*, *39a-c*, *40c-g*, 41

Plethodon cinereus in its different color phases is the most abundant species of the genus in the State and the most terrestrial in its habits.

Description

Size. This is one of the smaller salamanders and in New York State does not attain the size reached by individuals farther to the south. In a series of 600 specimens from Maplewood Park, Rochester, N. Y., measured by Hood (1934, p. 141) 157 adult males averaged 73.82 mm in total length with extremes of 58 and 91 mm. In this series the average body length is 40.55 mm and the tail, 33.27 mm. One hundred fifty-four adult females averaged 77.83 mm in total length, with extremes of 64 and 90 mm. In the females the average body length is 43.28 mm and the tail, 34.54 mm.

Form. The body is long and slender, slightly flattened dorsally, more strongly flattened ventrally in the trunk region and rounded on the sides. The tail is round in cross section for nearly its whole length but becomes slightly compressed toward the tip. The skin is fairly smooth and without conspicuously enlarged pores or glands.

The legs are small, short and relatively weak. The toes are short and thick, those of the fore feet 1-4-2-3 in order of length. The toes of the hind feet are thick and fleshy, webbed at base, and the inner one rudimentary; in order of length 1-5-2-4-3.

There are 18 or 19 costal grooves, the one in the groin usually forked above, but the number may vary from 17 to 20. Between the appressed toes there may be seven or eight costal folds.

The head is fairly long and narrow, widest immediately back of the eyes and slightly tapering to the bluntly pointed snout. It is usually somewhat depressed between the eyes and swollen dorsally behind the eyes. The head width is contained in its length about 1 2/3 times.

The eyes are large and prominent, the eyelids thick and fleshy. The horizontal diameter of the eye is about equal to the distance between the nostrils and is contained five times in the head.

The mouth is fairly large, with the angle of the jaw well behind the eye. The gular fold is prominent and continued on the sides of the neck. A well-marked horizontal groove extends from the eye

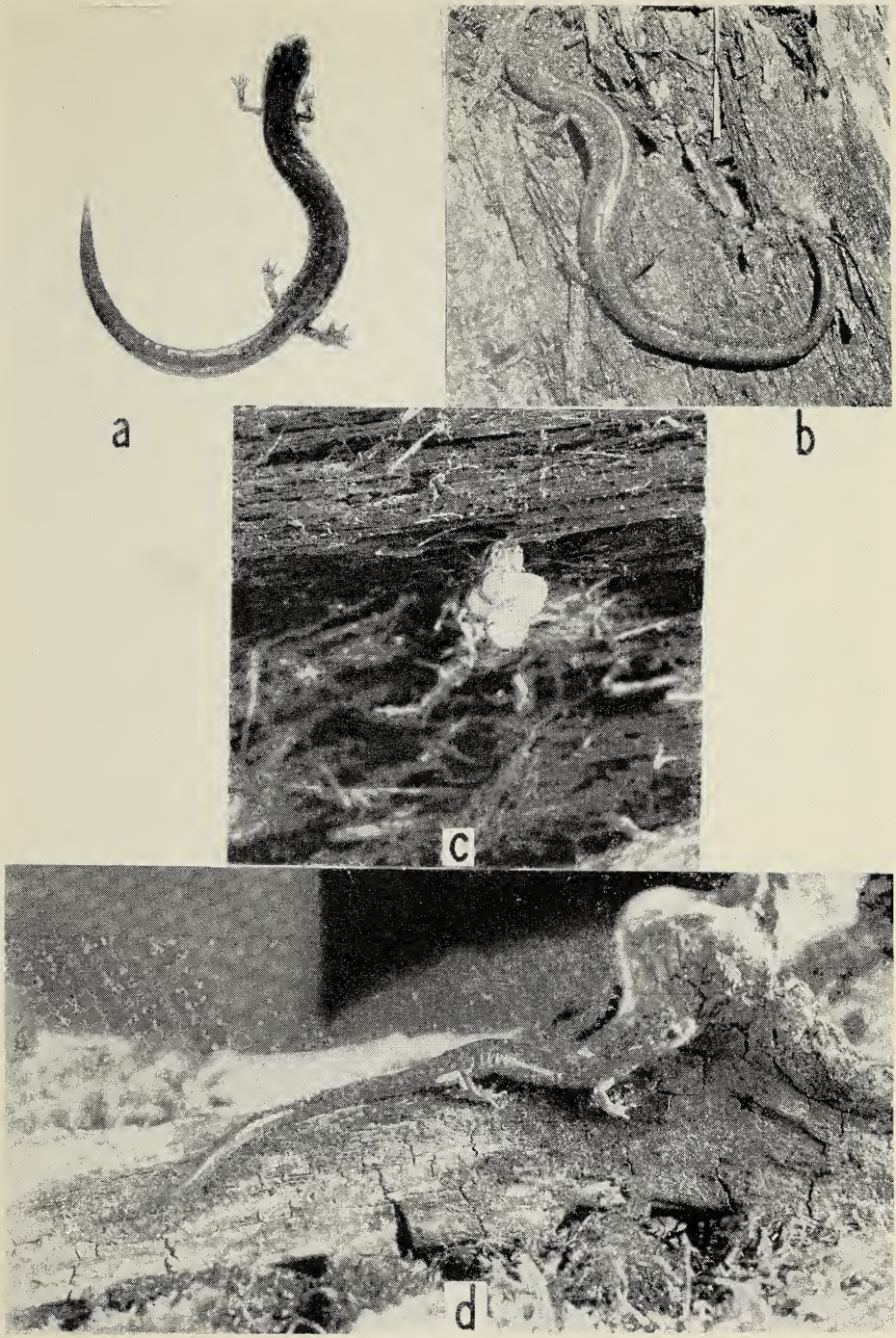


Fig. 39 a. *Plethodon cinereus*, red-backed phase, about natural size. Kenwood, N. Y. Apr. 23, 1923. b. Same, lead-backed phase, New Salem, N. Y., May 31, 1924. c. An egg-cluster of *P. cinereus* suspended in a crevice in an old hemlock log. McLean, N. Y., July 16, 1924. Photo by D. J. Leffingwell. d. *Plethodon wehrlei*, Port Allegany, Pa., Apr. 24, 1926. Adult about two-thirds natural size. Note the long slender tail.

to the gular fold, and a short, vertical groove from the angle of the jaw to the horizontal groove.

The tongue is only moderate in size and does not completely fill the floor of the mouth. It is attached medially in front and is thin and free at the sides and behind. The very fine plicae radiate mostly from a point near the posterior margin.

The inner nares are slightly closer together than the external. The vomerine teeth, in the male, are five in each series and form short, backward curving lines that begin opposite the outer margin of the nares. The vomerine series are separated from each other and the parasphenoid patches by a distance equal to one-half that between the inner nares. The parasphenoid teeth are in two elongate patches, narrow anteriorly where they are separate, broader behind and uniting at the posterior third. In the female, the parasphenoid patches may be narrowly separated their entire length and the vomerine series may include from five to seven teeth.

Color. The two color phases of this salamander were described by Green (1818, p. 356) at the same time and place. Early writers continued, for some time, to regard the red-backed individuals as distinct from those uniformly colored; moreover, the names, *cinereus* and *erythronotus* have sometimes been used to designate the two forms even when it was recognized that they were merely color phases of the same species.

The red-backed phase is characterized by the presence of a wide, median dorsal stripe that originates on the head, usually back of the eyes, and continues the length of the trunk and on the tail. In the majority of adults, the stripe is invaded by dark pigment on the distal third of the tail but in the young it continues to the tip. The color of the dorsal stripe is exceedingly variable, ranging from light gray and dull yellow through shades of pink, brick-red to bright red. Often there are small blotches of dark pigment within the band. The sides are darkest next to the dorsal light stripe, varying from brown through gray to black. The lower sides are usually strongly mottled, with pigment-free areas of irregular size and shape, while the sides of the tail are more uniformly dark colored.

The belly is strongly mottled gray and white, the throat lighter and flesh-colored in life. The lower surface of the tail is darker than the belly, mottled on the basal half and darker distally. The lower surface of the limbs is lighter than the belly. When the female is carrying well-developed eggs, the belly is yellow over which the dark pigment lies in strong contrast.

In the dark phase, the color above is dark brown to black, with the head and limbs usually a little lighter. The belly is lighter, gray and white mottled.

In addition to the typical color phases described above, I have encountered individuals intermediate, in some respects, between the two. In some, the dark pigment of the upper sides encroaches on the dorsal band and almost obliterates it; in others, the red of the dorsal band may be spread over the sides and rarely, the black pigment is lacking and the animal is uniformly red all over. I have found a single individual of this character, an adult from New Salem, N. Y., taken March 26, 1925. Reed (1908, p. 460), Reed and Wright (1909, p. 403) and Barbour (1914) also record all-red individuals.

Cope (1889, p. 136) remarks on the apparent scarcity of individuals of intermediate character and Piersol (1910, p. 469) found them rare in the Toronto region. J. A. Allen, however, (1869, p. 198) reported intermediates to be common in Massachusetts, and Reed (1908, p. 463) remarked that they were, "fairly numerous" in the vicinity of Ithaca, N. Y.

Often the two color phases are about numerically equal, Blanchard (1928*a*, p. 158) reporting 180 individuals (51.8 per cent) in a total of 348 collected near Ann Arbor, Mich. Blanchard further remarked that he "has searched in vain for evidence that the individuals of the two phases are otherwise than equally numerous in any locality and between the sexes." There is, however, considerable evidence that in some localities the one phase or the other may predominate or the one occur almost to the exclusion of the other. Dunn (1926, p. 167) has given some indication of this and his examples may be cited and further supplemented by additional records. Of 48 specimens taken by Dunn at Linville, N. C., only two were dark. Breder and Breder (1923, p. 14) collecting at Beaver creek, Ashe county, only 40 miles from Linville, found the dark phase common and the striped phase rare. Hurter (1911, p. 82) reported he had not found the dark phase west of the Mississippi in Missouri, and Cox (1898, p. 64) found only the red phase on the north shore of New Brunswick.

Cope (1889, p. 136) quoting Baird, remarks that "on the west side of Lake Champlain in Essex County, New York, Professor Baird states that he has found the red-backed salamander very common and never saw there the *P. cinereus.*" Weber (1928, p. 108) who collected at a number of localities in Essex County, N. Y.,

found only red-backed individuals and in our own collections from White Lake, Oneida County, only this form was represented.

On July 15 and 16, 1924, I collected with Dr A. H. Wright at McLean and Chicago bogs near Ithaca, N. Y., and among the many specimens encountered, including 16 females with eggs, no lead-backed individuals were found. On April 23, 1933, many specimens were found beneath old logs and boards at Blind Sodus bay, N. Y., but no lead-backed individuals. Finally, of 600 individuals collected in the gorge of the Genesee at Rochester during early spring and late fall months of 1929 and 1930, by Hood (1934, p. 141) 574 or 95.7 per cent were of the red-backed phase.

Sexual differences. Piersol (1910*a*, p. 473) writes of the red-backed salamander: "there is a total lack of secondary sexual characters." It has been indicated by Dunn, however, that in the males the snout is swollen in the region of the naso-labial grooves, the premaxillary teeth are enlarged, the vent papillate and the legs proportionally longer than in the females (1926, p. 165). Blanchard's measurements of series of 124 males and 101 females from the vicinity of Ann Arbor, Mich., show that, as a rule, the body length of males is shorter than that of females.

Measurements of 157 males and 154 females from Rochester, N. Y., not only show a shorter body length in the males but a recognizable difference in the tail length, as indicated in the paragraph dealing with the size of this salamander (Hood, 1934).

Migration. In this species there is no definite migration comparable with that undertaken by the species of *Ambystoma* and *Triturus,* and the nearest approach to a concerted movement takes place when the females congregate at the nest sites. Often only a single log will be found suitable in a bit of woodland and the gravid females make their way to it in numbers.

Mating. Piersol, whose accounts of the species are the best that have appeared, wrote in 1914 (p. 125) that "Means taken to determine the mating habits have so far been fruitless." This deficiency in the knowledge of the life history has in part been met by the contributions of Blanchard (1928) and Noble and Brady (1930, p. 52).

Blanchard (1928*a,* p. 160) found sperm in the cloaca of mature females on the following dates: October 31st, November 5th, 9th, December 9th, April 19th, 21st, 25th, 26th. These dates were represented by 34 specimens, of which 21 were taken October 31st. On this date only six mature females were found without sperm. Thus

the majority of specimens taken October 31st had already mated but in specimens collected on earlier dates no sperm were found.

Males with the vasa deferentia crowded with sperm were found on September 16th, 18th, October 24th, December 9th, April 17th, 19th, 21st, 23d, 26th, and May 13th. These dates were represented by 27 individuals. Of other adult males dissected within the limits of these dates only two of those taken April 5th and May 25th, had the vasa deferentia without sperm. The April 5th specimen had apparently just emerged from hibernation and the testes were full of sperm. The May 25th specimen was regarded as having already mated.

In the vicinity of Ann Arbor, Mich., it is quite apparent that there is an extended mating season beginning near the end of October and extending through the first weeks of spring (Blanchard, 1928*a*, p. 161). Noble and Brady (1930, p. 52) have studied the courtship of *Plethodon cinereus* in the laboratory and found that in general it agrees with other plethodontids, a description of which is given under the account of the four-toed salamander, *Hemidactylium scutatum* (p. 180).

Spermatophores. The first report on spermatophores of this species was made by Blanchard (1928*a*, p. 161). They were first noticed December 9, 1923, in each of two females found under leaves in close proximity with four adult males. On November 5, 1924, Blanchard found another female with a spermatophore held in the cloaca and four days later one additional specimen. Six more females were collected October 31, 1926, each with a spermatophore. Altogether ten specimens were taken between October 31st and December 9th. As indicated above, it was within the limits of these dates that mature females with sperm in the cloaca were found in numbers.

Blanchard (*ibid.*, p. 161) described the spermatophores as being "pure white, subspherical bodies tucked closely into the posterior part of the cloaca. They resembled the eggs of this species but were smaller. They seemed to be nothing more than sacs or bags filled with sperm." Blanchard also thought it probable that spermatophores were directly transferred.

Noble and Weber (1929, p. 5) also mention a female *Plethodon cinereus* taken November 4, 1928, at Yonkers, N. Y., which had a spermatophore within its cloaca. A gelatinous base was attached to the spherical whitish mass and indicated that in this species, as in other plethodontids, stalked spermatophores are probably deposited

on the ground. In my own experience, several females with spermatophores have been found in the fall months.

Under normal conditions, it is probable that the mating season in the fall is an extended one, as indicated by the studies of Blanchard. It is apparent, however, that under certain conditions, mating activities may be suspended and a large proportion of the males may mature the sperm and store them temporarily in partially formed spermatophores held in the vent. Evidence in support of this contention was found in the fall of 1929 when every one of 55 mature males collected on October 7th and examined by Helen H. Hood was found to be carrying a spermatophore in the vent. In the females taken on this date there was no evidence of spermatophores but on October 16th many of the 25 adults taken were carrying them.

At Rochester, N. Y., 1.15 inches of rain fell during the period of three weeks prior to October 2, 1929. On October 2d there was a two-inch fall of rain followed October 6th and 7th by a marked rise in temperature which Hood suggests may be correlated with the activity of the males in producing spermatophores. Mating actively followed during the week of October 7th to 16th and many females were carrying spermatophores in the vent or sperm in the spermathecae.

The nest site. There is no definite nest constructed, the female merely selecting a suitable situation for her eggs.

In the field they are deposited in a variety of situations but the majority of those I have found were in crevices in well-rotted logs. On one occasion, while collecting with Dr A. H. Wright and W. J. Schoonmaker at Chicago bogs near Ithaca, N. Y., a female with six eggs was found in the side of a rotten stump.

Usually the stump or log in which eggs are found is one that has disintegrated to such an extent that it may be pulled apart with the hands. Here in crevices in the log itself or in cracks under the bark the eggs are deposited in little clusters and attended by the female. A situation is chosen that will permit the female to be in contact with the eggs which may be attached to a support or simply form a compact group attached to one another. The eggs are most frequently found near the ends of logs, in my experience, probably because the crevices are more easily accessible. Sometimes as many as half a dozen females with their eggs may be found in close proximity in a single log.

Putnam (1865, p. 173), who first described the eggs of this species, found them August 26th, 27th, 29th, under the moss and

bark of decayed trees. Sherwood (1895, p. 32) remarked, "The eggs are laid in damp moss and under bark of decayed trees." Ditmars (1905, p. 171) reported the eggs, "under damp and decaying logs, in moss or under stones." According to Reed and Wright (1909, p. 403), "The eggs are deposited during June and July, under logs, loose bark or in decaying wood, in bunches of from seven to twelve." Cochran (1911, p. 332) who studied the red-backed salamander in the region about Worcester county, Mass., reported, "The eggs are laid beneath stones in July and early August. One of the parents, usually the female, broods them." Rarely, both the male and female may be found with the eggs.

Piersol (1910*a*, p. 473) summarizes his observation as follows:

As a situation for the eggs marked preference is shown for logs almost entirely embedded in the humus, logs that have decayed to a point where the substance is friable with large cracks running lengthwise. In one of these cracks the eggs are hung from the roof like a little bunch of grapes. Rarely a similar cavity within a decaying stump is selected. All the localities in which Plethodon has been found contain conifers and almost without exception it is in coniferous wood that the eggs have been found; though the adults may be found plentifully in wood of all kinds. Usually the eggs are placed from three to five inches beneath the surface of the log, at which depth its substance is constantly moist, and it can well be imagined that the air is saturated with water vapor.

They are always accompanied by the female and if in exposing them she has not been alarmed, she will be found holding the dorsal surface of her head and neck against the under side of the bunch. That it is the female that is on guard was determined by the dissection of over twenty specimens. In only one case was a male found by eggs and then in company with a female; the eggs were several days advanced in development and the presence of the male was perhaps merely an accident.

It has been my own experience that the female accompanies the eggs although not always in the position indicated by Piersol. On several occasions the female has been found with her body curled around the egg cluster. Montgomery (1901, p. 503) also mentions a case where the eggs were guarded by a female that curled around them, and in a later paper Piersol (1914, p. 121) himself records such an occurrence.

The majority of observers indicate that the eggs are usually found in or about old logs or stumps. Cope (1889, p. 134), Montgomery (1901, p. 503) and Cochran (1911, p. 344), report them from beneath stones and I have one record, June 17, 1927, from Warner's Lake, N. Y.

The egg-laying process. The deposition of the eggs of the red-backed salamander has been observed in the laboratory by Piersol (1914, p. 121), who states:

On one occasion the actual extrusion of the eggs was observed. The female had been placed when captured in a small glass jar along with fragments of the log in which she was found; and the jar with others containing eggs was carried back to the laboratory in a small bag. Chiefly for the sake of the eggs which are very delicate the bag was guarded from shocks as far as possible, then for another hour it stood unopened. On removing the jar from the bag it was seen that the egg laying had just begun, fortunately in such a position that all its details could be observed. The lips of the cloaca are pressed against the surface from which the eggs will eventually hang and a small quantity of mucus is extruded and adheres firmly to it. This much had been completed before observation began so nothing can be said as to the interval that then elapses before the first egg is laid. The extrusion of each egg occupies about twenty seconds and an interval of five to ten minutes occurs before the next appears. The first three eggs were laid in contact with the mucus above mentioned; the fourth, and last, adhered to them in turn through the stickiness of the egg-envelopes. As the female did not move during the entire process, all the eggs were laid at the same point, each egg as it came, crowding the preceding ones aside, thus making sure of being in contact with them. For over an hour after the last egg was laid the female did not change her position; during the next hour she left the eggs a few minutes. then returned and coiled herself about them.

The egg mass. The eggs are usually deposited in a small cluster and suspended at the top of the cavity chosen for the nest. As indicated in an earlier paragraph, they are sometimes found on the floor of the cavity but whether they had been attached and tumbled to the position in which they were found or had been deposited in that situation, it is impossible to say. On July 15, 1924, a cluster of nine eggs attended by a female was found lying on the floor of a little cavity in a rotten log at Chicago bogs near Ithaca, N. Y., and as there was no indication of a pedicel for attachment, they may have been deposited where found. Piersol (1914, p. 123) also noted eggs so disposed and in addition mentions the occasional finding of eggs deposited singly and somewhat scattered.

The number of eggs that may be deposited by a single female varied from 5 to 13 in 91 adult females dissected by Blanchard (1928, p. 158). These figures are in substantial agreement with those obtained by counting the eggs in clusters found in the field. Piersol (1910*a*, p. 474) gives 3 to 12. Often clusters are found with fewer

than five eggs but in these instances, it is likely that the entire complement had not been deposited.

In Blanchard's graph (1928, p. 159, figure 3) it is indicated that only two females were found in which 5 eggs were present, four with 6 eggs, eight with 7 eggs, 18 with 8 eggs, 18 with 9 eggs, 17 with 10 eggs, 12 with 11 eggs, seven with 12 eggs and two with 13. It is here evident that over 50 per cent of the females had deposited from 8 to 10 eggs per mass.

In New York State I have recorded egg clusters as follows: at Chicago bogs near Ithaca, two sets containing 6 and 9 eggs respectively were found July 15, 1924; at McLean, July 16, 1924, 14 sets of eggs all attended by red-backed females, four with 5 eggs each, three with 4 each, two with 3 each and single sets containing 1, 6, 7, 9 and 10 eggs; at Van Etten, August 4, 1924, one set of 6 eggs; Syracuse, July 15, 1916, one set of 11 and July 26, 1916, one with 10 eggs; Halcottsville, July 16, 1913, A. M. N. H. No. 16,803, one set with 9 eggs; Wilmurt, August 3, 1902, State Mus. No. 29, one set of 9 eggs.

Females guarding eggs were reported by Bishop (1927, p. 48) from Allegany State Park, from the hillside between Willis and Coon creeks, August 10, 1926, and Blacksnake mountain, August 17, 1926. From this same general locality Dr R. E. Coker collected well-developed embryos July 25, 1927. Burt (1932, p. 76) reported females with eggs July 25–28, 1931, at the following localities: Blue Mountain lake, one set; seven miles east of Saranac lake, three sets; and near Raquette lake, one set.

Development

The egg and its envelops. The eggs vary in size from 3.5 to 5 mm. Freshly deposited eggs are smaller than those which have absorbed moisture and with the growth of the embryo, the size is still further increased.

The majority of eggs in any particular cluster are remarkably uniform in size; in about 50 per cent of the sets, one egg may be markedly smaller (Piersol, 1914, p. 125). Frequently one or more small eggs are retained in the ovaries and are reabsorbed. Considerable variation in size exists among eggs of different clusters and the difference may not always be attributed to the amount of moisture present, for the size of the yolk itself may vary.

Shortly after deposition and before there is any considerable development, the egg and its envelops may measure only 3 to 3.5

mm. After the embryos have developed the gills and limb buds the diameter may be 4 to 5 mm.

The egg is yellow and without pigment. The color varies somewhat among different clusters but the range is a slight one, from pale cream to light orange-yellow, as indicated by Piersol (1910*a*, p. 476).

Surrounding the yolk the envelops are disposed as follows: (1) the usual vitelline membrane closely surrounding the yolk and scarcely discernible until segmentation breaks the smooth contour of the surface; (2) the second envelop is itself thin and elastic and incloses a watery fluid; (3) the third and outermost layer is somewhat thicker but varies with the amount of moisture present in its surroundings. The outer surface of the third layer is fairly tough, often presents a fuzzy appearance and, as noted by Piersol *(ibid.,* p. 475) seems to be covered by threads and bands of milky-white mucus. The eggs cling to one another by the adhesiveness of these outer mucus strands which often converge to form the attachment stalk.

The incubation period. So far as I am aware, no one has determined the length of the incubation period under natural conditions in the field. Piersol (1910*a,* p. 478) writes of eggs hatching about the first week of September but without indicating when the eggs may have been laid.

My earliest record for eggs is June 17, 1927, when a cluster was found attached to the lower surface of a stone at Warner's Lake, N. Y., by Edna and Albert Were of Albany. These were apparently freshly laid. Piersol (1910*a,* p. 473) gave June 16th as the earliest date on which eggs were found in the Toronto region. The latest date for fresh eggs in the same region was July 3d. Unhatched eggs may be found through July and August, the latest date of hatching I have recorded being August 31, 1926, at Allegany State Park. Additional records of hatching eggs are as follows: Blacksnake mountain, Allegany State Park, August 19, 1926; Hillsgrove, Pa., August 3, 1924.

Sherwood (1895, p. 32) mentions eggs of this species, "Found October 25." This is exceptionally late for *Plethodon cinereus.* The eggs reported by Putnam (1865, p. 173) from the vicinity of Warwick, Mass., were found August 26th, 27th and 29th, 1864. Montgomery (1901, p. 503) found eggs in which the larvae were well developed July 5th. Many other dates might be given but usually there is no way of determining from the accounts the stage of development the eggs had reached, and they have little significance.

Abbott (1884, p. 343) thought that this salamander laid eggs in June and again in August but the length of the incubation period during which the female is attending her eggs, would preclude this possibility.

The newly hatched larva. The recently hatched larvae I have measured varied from 18.5 to 19.5 mm with the average length of 19 mm. Piersol (1910*a*, p. 482) gives the length as 20 to 25 mm and Cochran (1911, p. 347) as 20 mm.

The eggs I have been able to carry through to hatching have all developed into red-backed individuals and were attended by red-backed females. Cope (1889, p. 136) remarking on the constancy of the color varieties, indicates that all the young of the same set of eggs were either red-backs or dark-backs and that he had found red-backed females with red-backed young and dark-backed females with young of the same color. Burger (1935, p. 581), however, "repeatedly found both phases in the same set of eggs. . . ."

At the time of hatching and, in fact, some time before, the color pattern is well developed. The median dorsal light band is obscured on the snout and dorsal surface of the head by dark pigment, but becomes distinct as a broad band above the gills. It narrows somewhat above the fore legs and continues the entire length of the trunk with its slightly scalloped edges nearly parallel. At a point above the hind legs, the band begins to taper and follows the tail to its tip. The band is lightly pigmented above and the midline is marked with a fine line of dark dots. The upper side of the trunk and tail next to the dorsal band is strongly pigmented, the color gradually fading on the lower side where it is invaded by many rounded, pigment-free areas, variable in size and shape. On the side of the head a dark band extends through the eye to the nostril, below which, back of the eye, there is a narrow light line. The legs are pigmented and blotched above like the lower sides. The throat, lower surface of the limbs, and the midline of the belly and tail are free from pigment.

At hatching the eyes are large and prominent. The hind feet have the toes well indicated but the inner and outer are short and budlike. The fore feet have the four toes well formed but without indication of joints, the outer and inner short.

The gills may reach their greatest development while the embryo is still within the egg envelops and then reduce them somewhat before hatching; or the larvae may hatch with the gills only one-half their ultimate size, attain their complete growth in a day or so and reduce

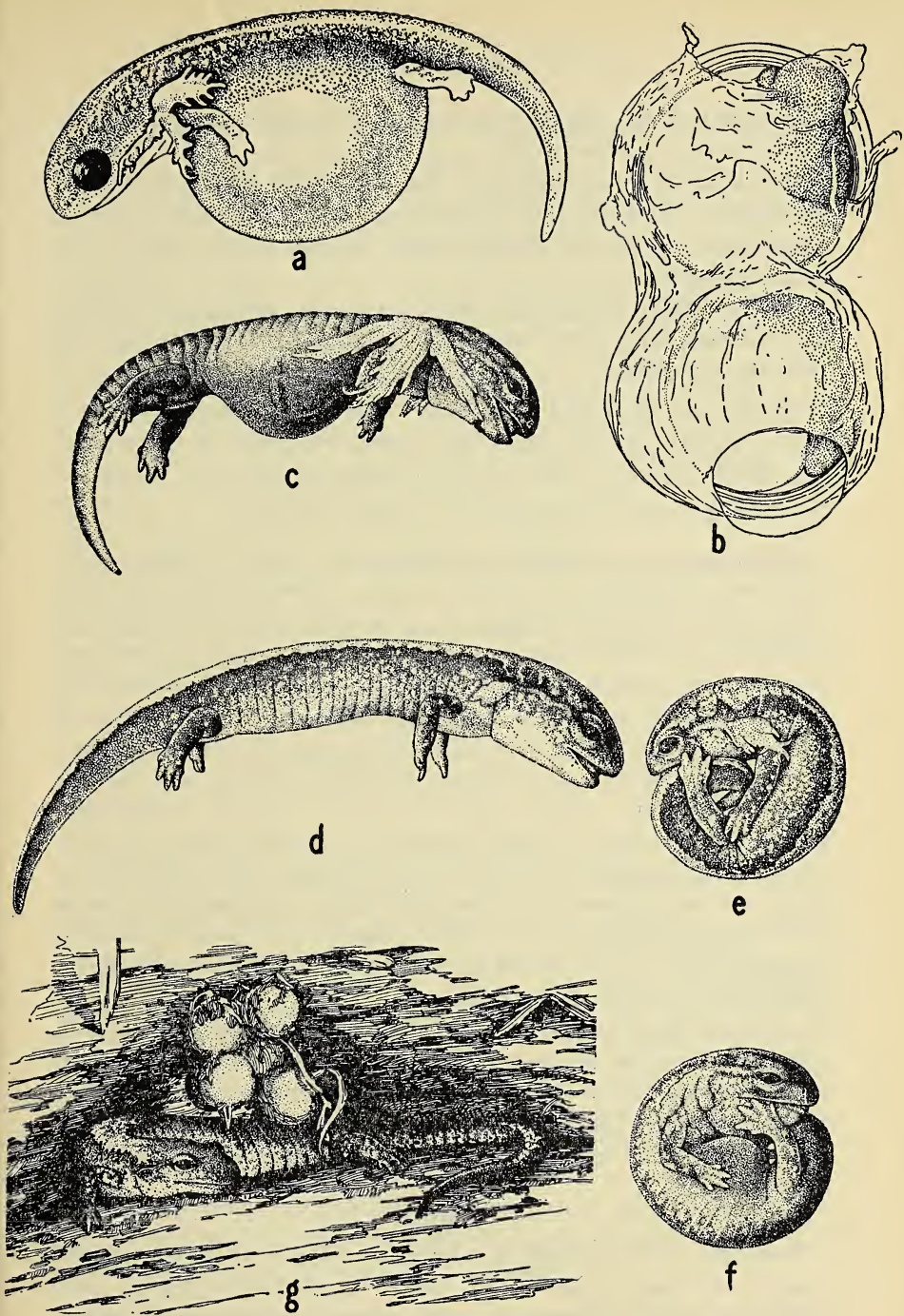


Fig. 40 a. *Plethodon glutinosus*, young larva (after Noble) H. M. Z., del. b. Same, encapsuled larvae (after Noble). H. M. Z., del. c. *Plethodon cinereus*, larva at hatching, Allegany State Park, N. Y., Aug. 17, 1926. Actual length, 18 mm. H. E. R., del. d. Same, larva two days after hatching. e. Same, larva removed from egg-envelops. Allegany State Park, N. Y., Aug. 31, 1926. H. E. R., del. f. Same, opposite side. g. Adult female guarding eggs. McLean, N. Y., July 16, 1924. H. E. R., del.

them greatly in an additional 24 hours. The gills may be lost completely in two or three days.

When fully developed, the gills are free from pigment, broad, flat and leaflike. They arise from a common base and the length of the longest may exceed the distance from the end of the snout to the base of the gill.

A considerable amount of yolk is present at hatching and doubtless sustains the young salamanders until they can disperse and shift for themselves.

The length of the larval period. The gills are retained at most only a few days after hatching and external evidence of transformation in this species is limited to their reduction and loss. There are no striking changes in proportions, color or pattern.

Development to maturity. Blanchard's studies (1928, p. 156) have shown that in the Ann Arbor region, "Breeding age is attained at the end of the third season, i.e., at about two years of age, and the first eggs are laid in the spring of the fourth season." These conclusions were reached from the study and measurements of series of specimens taken in October and November. Our own studies of New York material collected at Rochester, is based on measurements of individuals taken during October and again in April and May.

Blanchard (*ibid.*, p. 159) found that on the basis of size his individuals fell into three groups, the group of smaller individuals composed of the young of the year and the groups of the largest ones almost entirely of sexually mature individuals. In Blanchard's curve based on measurements of body length, the three prominent eminences were at 17, 30 and 43 mm, with minor points indicating a difference in the size of the sexes.

A curve, based on the measurement of body length of 600 individuals collected at Rochester, N. Y., and measured by Helen H. Hood, indicates that the juveniles fall into two groups with eminences at 16 and 30 mm, and the adults show prominent points at 42 and 44 mm, the latter figure indicating the slightly greater body length of the females.

Habits

General. The red-backed salamander is entirely terrestrial and usually nocturnal in its habits. When revealed in its hiding place beneath some log or stone it rarely attempts an immediate escape and frequently remains quietly curled in the position in which it was found. If prodded or touched it sometimes responds by rushing rapidly away, the relatively feeble legs aided by looping movements

of the trunk and tail so that the animal appears to be progressing by a series of rapidly executed leaps.

The leaping ability of this species has been noted by Cope (1885, p. 313), Cope (1889, p. 139), Piersol (1910*a*, p. 471), Cochran (1911, p. 337) and Murphy (1917, p. 105). The legs apparently function very little in the process, the tail acting as the important organ in propulsion. Murphy (*ibid.*) sees in the leaping ability of this species the possible origin of saltation in the ancestors of the Anura but since entirely different muscles are involved, it is difficult to see how the anurans, which use the hind legs, could have acquired the habit from forms that make use of body and tail muscles.

This species in spite of its small limbs, is an excellent climber. It can make its way up the vertical sides of a vivarium or cling to the lower surface of an upturned log or piece of bark.

Frequently specimens are found with partly regenerated tails and sometimes when a log or stone is turned, a portion of the tail will be found detached from the body and wriggling violently. It has long been known that the species practises autotomy and that any part of the tail from a point a short distance behind the vent may be thrown off. There is no specialized device as in the four-toed salamander, *Hemidactylium,* but the same provision is made for covering the stub. The process has been well described by Piersol (1910*a*, p. 472) as follows:

> Separation of the vertebral column occurs between vertebrae. . . . In the muscle the myomeres are not broken but separation occurs in the myocomma opposite the middle of the last vertebra retained. The skin, however, does not break here but at the myocomma opposite the middle of the first vertebra of the piece cast off. Two things are accomplished by this; first the wound that now terminates the animal's tail is protected by the extra length of skin which collapses laterally upon it and almost covers it in. Second, on the piece cast off considerable raw surface is left exposed, the irritation from which is doubtless largely responsible for the rapid contortions that occur. This piece must play an important part in the protective device for by its violent movements it would draw the attention and invite the first attack of an enemy.

The red-backed salamander can swim but its movements are labored and every attempt is made to escape from the water into which it apparently never enters voluntarily.

Food. A number of studies have been made of the food of this species and many additional notes are scattered through the literature. Cochran (1911, p. 339) listed the food found in 15 stomachs: "Ants of several kinds, beetles of several kinds, bugs, caterpillars

(cutworm), centipedes, earthworms, fleas, flies of several kinds, maggots (rat-tail), midges, mites, mosquito wiggler, plant lice, plant remains, pseudoscorpion, slugs *(Limax),* spiders, spring-tail *(Thysanura),* sow-bug, wasp-like insects." The inclusion of a mosquito larva and rat-tail maggots in the diet suggests that some of the salamanders had been feeding in the immediate vicinity of water or at least in very damp situations. Surface (1913, p. 95) reporting on the stomach contents of 260 specimens listed, "snails, earthworms, spiders, mites, thousand-legged 'worms,' insect larvae and adult insects, of which ants formed a large part."

Murphy (1917, p. 105; 1918, p. 8) mentions bibionid flies, winged ants and Collembola among the more active insects captured by this species.

The items in the diet reported by Smallwood (1928, p. 91) include the following given in order of abundance: "ants, earthworms, beetles, centipedes, pill-bugs, snails, mites, insect larvae, spiders, *Julus,* spring-tails, roundworms, flies and grasshoppers." Smallwood noted that both males and females captured during the breeding season had taken very little food.

Blanchard (1928, p. 162) reported the following:

Examination of seventy stomachs from specimens taken at various dates in spring and autumn showed twenty-nine to contain beetles; nineteen, ants; seventeen, spiders; ten, small snails, mostly flat-coiled; six, millepeds; five, bugs; four, mites; three, springtails; three, pseudoscorpions; two, earthworms; and one each, weevil, sow-bug, pupa, hymenopteron, maggots, roach, inchworm and amphipod. Various insect larvae were found in twenty-five stomachs, and miscellaneous unidentified small insects in thirty-four stomachs. This is practically a verification of the findings of Surface (1913). It shows a preference for and ability to catch relatively large-sized and active forms, mostly insects, but also, prominently, spiders, snails and millepeds. Shed skins were found in twelve stomachs. How often the skin is shed and whether it is regularly eaten seem questions yet to be answered. In addition to the seventy individuals whose stomachs contained food, eleven examined had empty stomachs. These represented various dates on which individuals with full stomachs were obtained. Most stomachs contained a variety of contents, but in a few cases a single form made up the bulk; the contents of one stomach, for example, was made up largely of a mass of black springtails, and another stomach was crowded with ants.

The most recent study of the food of this species is by Hamilton (1932, p. 85) whose specimens were taken in the vicinity of Ithaca, N. Y. He states:

Two hundred fourteen stomachs examined. Fifty-seven per cent of the food eaten constituted insect remains. About half of these

were ants, a third small beetles and the remainder lepidopterous larvae, Diptera and undetermined insects. Spiders and mites make up 17 per cent; sowbugs, 11; extraneous matter, cast skins and small worms form about 12; while a trace of small molluscs, thrips and undetermined matter make up the remainder. A small acarinid spins a silken cocoon on the fallen needles of hemlock. The salamanders must have either a keen sense of sight or smell, for many stomachs contain a single needle, with the attached cocoon and enclosed arthropod, which does not equal a tenth of the volume that the leaf occupies.

Altogether the food consists of the animals commonly found on or near the ground in terrestrial situations and is mostly limited to the smaller forms.

Habitat

The red-backed salamander is more completely adapted to terrestrial life than any other species in the State. It is abundant in evergreen, mixed and deciduous woods under moss, bark, logs and stones. It may abound in situations that are comparatively dry but usually there is access, by burrows or crevices, to sources of moisture. In dry periods it may disappear completely from its usual haunts and remain deeply buried during the drought. In Maplewood Park, Rochester, and in Letchworth Park, where, under favorable conditions several dozen may be collected in the course of a few hours, not a single individual could be found during dry periods in 1932. Later in the season, following rains, they were again abundant.

While it is true that many individuals are found far from any visible water supply and the species is less dependent on water than many others, I have found them in greatest numbers in fairly damp situations. In the low grounds bordering woodland streams near Albany, N. Y., they are particularly numerous and it is my impression that here, at least, the lead-backed phase predominates.

In certain parts of its range, the species is associated with the Jefferson salamander, particularly in the fall of the year when the young of that species congregate beneath pieces of bark and old logs. In the spring and fall it may sometimes be found sharing its shelter with the four-toed salamander.

Rarely is the species found abroad during daylight. On dark days and during quiet rains it sometimes ventures out but I have observed them only at infrequent intervals.

Remarks

Baird (1850, p. 285) was apparently the first to mention the eggs of this species and indicated that they were laid in packets under damp stones. Putnam (1865, p. 173) gave the first description of

the eggs which were found under moss and bark of decayed trees near Warwick, Mass.

Montgomery (1901, p. 503) mentioned a single lot of eggs found beneath a damp stone in July near West Chester, Pa., and gave the first descripton of the larval stages.

Piersol (1910*a*, 1914) and Cochran (1911) have given detailed accounts of the life history and habits and the former a description of the actual deposition of the eggs. Dunn in 1926 summarized practically all that was known of the species and in 1928 Blanchard reported the discovery of spermatophores and gave additional information on size groups, mating seasons and breeding age.

Eights (1836, p. 130) seems to have been the first to record the species in New York State.

Plethodon cinereus is closely related to *Plethodon dorsalis,* from which it differs in easily recognized color characters and usually in the costal groove count, and to *Plethodon vehiculum* (Cooper), the western red-backed salamander.

Range

"Cape Breton Island west to Fort William, Ontario, south to Dallas, Georgia, Missouri and Arkansas." (Stejneger and Barbour, 1933, p. 10.)

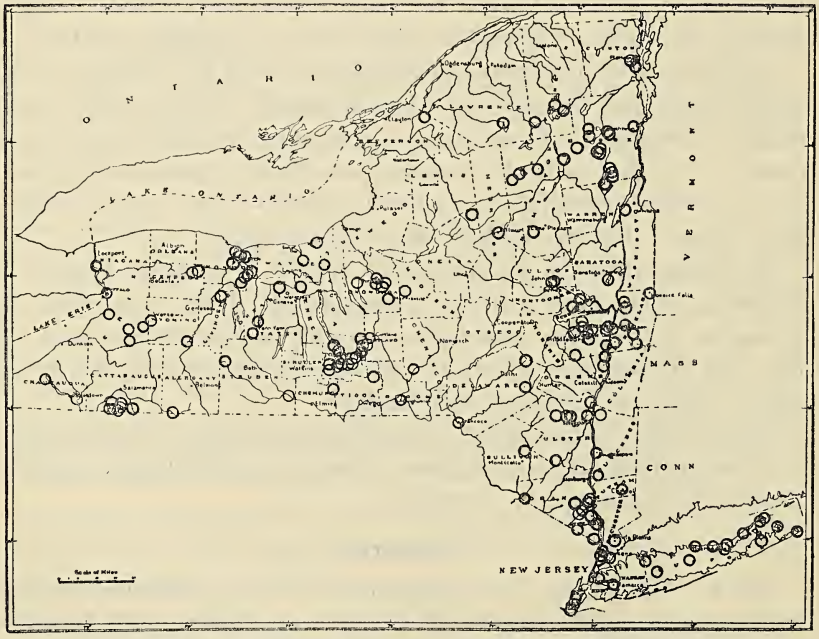


Fig. 41 New York localities for *Plethodon cinereus.*

Distribution in New York

General. Widely distributed throughout the State in suitable localities.

Specific records. ALBANY: *Albany* (Eights, 1836; 62d Ann. Rep't N. Y. State Mus., 1909); Apr. 4, 1920, 3 spec., N. Y. S. M. No. 8665–67; Apr. 10, 1922, 14 ads. and juv.; Apr. 16, 1922, 1 ad.; Apr. 14, 1924, 3 spec.; Aug. 2, 1927, 5 ads., N. Y. S. M. No. 3942–43 (S. C. B. and W. J. S.); *Altamont,* June 25, 1902, 1 spec., N. Y. S. M. No. 44 (F. C. Paulmier); *Clarksville,* May 7, 1926, 2 spec. (S. C. B. and B. S. Bronson); *Kenwood,* Oct. 3, 1901, 16 spec., N. Y. S. M. No. 7 (F. C. Paulmier); Oct. 10, 1901, 1 spec. (F. C. Paulmier); June 2, 1908, 1 ad., N. Y. S. M. No. 89 (F. H. Ward); *Medusa,* Apr. 13, 1922, 4 ads., N. Y. S. M. No. 9139; *New Salem,* May 6, 1923, 1 spec., N. Y. S. M. No. 9483; Apr. 5, 1924, 1 spec., N. Y. S. M. No. 1479, (S. C. B. and W. J. S.); Mar. 26, 1925, 1 spec. (S. C. B. and W. J. S.); Mar. 27, 1925, several spec.; Apr. 23, 1925, sev.; May 8, 1925, 1 spec.; Apr. 13, 1926, 5 ads. (S. C. B., W. J. S. and H. H. Cleaves); Apr. 21, 1926, 1 spec. (S. C. B. and W. J. S.); Apr. 29, 1926, several spec. (S. C. B. and B. S. Bronson); Apr. 13, 1927, 1 spec. (S. C. B. and E. J. Stein); June 28, 1927, several spec.; *Normansville* (Bishop, 1923); *Selkirk,* Sept. 15, 1924, 6 spec. (S. C. B., J. Eaton and W. Peltz); *Thacher Park,* May 4, 1904, 1 ad., N. Y. S. M. No. 73 (F. C. Paulmier); Oct. 1, 1922, 1 spec. (A. Wolf); Aug. 3, 1927, several spec.; Aug. 31, 1927, 2 ads. (S. C. B. and D. Cook); *Voorheesville,* Nov. 4, 1922, 7 spec., N. Y. S. M. No. 9415–21; Apr. 4, 1923, 1 spec.; Apr. 30, 1927; Oct. 14, 1933, 5 spec., U. R. No. 3261 (S. C. B. and B. S. B.); *Warner's lake,* June 17, 1927, eggs (Edna and Albert Were). ALLEGANY: 2 spec. (Yarrow, 1882; Cope, 1889); 2 spec., U. S. N. M. No. 3768 (Stevens); *Ceres* (7th Ann. Rep't State Cab. Nat. Hist. 1854). BROOME: *Binghamton* (G. Bump). CATTARAUGUS: *Allegany State Park,* July 14, 1927, 1 ad. (W. P. Alexander); Oct. 19, 1934, several, U. R. No. 3436; *Blacksnake mountain,* Aug. 17, 1926, 2 ad. ♀ and eggs, N. Y. S. M. No. 3102 (Bishop, 1927); July 10, 1931 (H. Jack); June 9, 1933, 3 spec., U. R. No. 3119 (S. C. B., H. Chrisp, C. Zorsch, K. Lagler); *Coon run,* Aug. 3, 1922, 7 ads. (Bishop, 1927); between *Coon run and Willis,* Aug. 10, 1926, 3 ads., N. Y. S. M. No. 3204–06 (Bishop, 1927); *Mount Cayuga* (summit), Aug. 29, 1926, 1 ad. (Bishop, 1927); Frecks, Aug. 10, 1926, 1 ad. ♀ and eggs; *Natural History School,* July 25, 1927, 2 spec. (R. E. Coker); Oct. 10, 1931, U. R. No. 2182; Oct. 10, 1936, ads.; Aug. 27, 1937, ads; Oct. 24, 1937, ads; May 7, 1938, abdt.; Oct. 15, 1938, sev.; *Seneca Mt.,* Aug. 24, 1926, 1 ad. (Bishop, 1927); *Tunungwant valley* near *Limestone,* Aug. 22, 1926, 2 ads., N. Y. S. M. No. 3168–3169 (Bishop, 1927). CAYUGA: *Duck lake* (Wright and Moesel, 1919). CHAUTAUQUA: *Chautauqua,* 1908 (Reed, 1908); *Poland Center,* Sept. 12, 1937, 3 ads. CHEMUNG: *Van Etten,* Source of Wyncoop and Baker creeks, Aug. 4, 1924, ♀, eggs (Karl Van Deman). CHENANGO: *Greene,* Dec. 2, 1922, 5 ads. (W. Bartlett); Apr. 19, 1928, 4 spec., N. Y. S. M. No. 4694 (W. Bartlett); May 4, 1928, 2 ads., N. Y. S. M. No. 4719 (W. Bartlett). CLINTON: *Plattsburg* and *Valcour Island* (Hudson); *Plattsburg,* Sept. 11, 1904, 1 spec. (F. C. Paulmier); *Valcour Island,* Aug. 11, 1917, 1 ad. (S. C. B. and A. S. B.). CORTLAND: *Chicago bogs,* May 17, 1924, several spec. (F. Harper); July 15, 1924, 2 ♀ and eggs (S. C. B., A. H. Wright and W. J. S.); Oct. 10, 1933, 1 spec., U. R. No. 3259 (W. J. Koster); *Gracie,* Beaverbrook, May 2, 1934, 2 ads.; *McLean,* May 2, 1934, 4 ads. DELAWARE: *Halcottsville,* July 26, 1913, 1 ad., A. M. N. H. No. 16,803 (A. H. Helme); *Hancock* (G. Bump); *Stamford,* Oct. 10, 1933, 4 spec., U. R. No. 3260 (H. P. Chrisp). DUTCHESS: *Fishkill,* Sept. 28, 1904, 2 ads., N. Y. S. M. No. 73 (F. C. Paulmier); *Poughkeepsie,* Apr. 6, 1878 (Smith, 1882); *Red Hook,* July 20, 1938, ads. (Van Auken). ERIE: *Buffalo,* Sept. 9, 1905, C. U. (A. A. Allen); 1908 (Reed, 1908); *Hamburg, Glenwood,* 1925 (R. R. Humphrey); *Holland,* 3 Valley Nature Reserve, Aug. 1–16, 1930, 5 spec., U. R. No. 2120 (E. Hilfiker); *Springville,* Sept. 26,

1928, 2 spec. (F. J. Holl). ESSEX: *Adirondack Lodge,* July 2, 1923, 2 ads.; *Alder pond* and *creek,* June–Sept. 1926 (J. A. Weber, 1928); *Avalanche lake,* July 29, 1926 (F. Harper and W. J. S.); *Boreas Mountain,* June–Sept. 1926 (J. A. Weber, 1928); *Chapel Pond pass,* June–Sept. 1926 (J. A. Weber, 1928); *Clear pond,* June–Sept. 1926 (J. A. Weber, 1928); *Elk lake,* June–Sept. 1926 (J. A. Weber, 1928); *Mount Pharaoh,* June–Sept. 1926 (J. A. Weber, 1928); *Newcomb,* Oct. 5, 1917, 1 ad., N. Y. S. M. No. 3782 (S. C. Bishop) (72d Ann. Rep't N. Y. S. Mus., 1919); *Paradox lake, Severence,* June–Sept. 1926, (J. A. Weber, 1928); *St Huberts,* Sept. 1, 1921, 2 ad., A. M. N. H. No. 14,542–3; *Lake Sanford,* June–Sept. 1926 (J. A. Weber, 1928); *Westport,* 20 spec., U. S. Nat. Mus. No. 3758 (Yarrow, 1882; Cope, 1889). FRANKLIN: Island in *Saranac lake* (DeKay, 1842); near *Saranac Inn,* July 25–28, 1931, several spec. (Burt, 1932); near *Tupper lake,* July 25–28, 1931 (Burt, 1932). FULTON: *Gloversville,* May 12, 1906, 3 spec. (C. P. A.); Oct. 1, 1906, N. Y. S. M. No. 85 (C. P. A.); *Johnstown,* May 16, 1908, 2 ads., N. Y. S. M. No. 96 (C. P. A.). GENESEE: *Bergen swamp* (Wright and Moesel, 1919); June 8, 1929, sev. spec.; Oct. 12, 1929, several spec. (S. C. B. and C. Bentley); May 28, 1933, U. R. No. 3013; Apr. 17, 1937, ads.; Apr. 29, 1937, ads.; May 25, 1938, ads. GREENE: *Coxsackie,* 6 spec., U. S. N. M. No. 16282 (S. F. Baird); 1851, 2 spec. (Yarrow, 1882; Cope, 1889); *New Baltimore,* Aug. 1893, N. Y. S. M. (W. B. Marshall); *Beach's Corners,* Hunter, Sept. 4, 1938 (Leffler). HAMILTON: near *Blue Mountain lake,* July 25–28, 1931, 1 ad. ♀ and eggs (Burt, 1932); *Eighth lake,* Aug. 1925 (R. R. Humphrey); *Piseco,* 1 spec., U. S. N. M. No. 36979 (W. L. Ralph); near *Raquette lake,* July 25–28, 1931, ♀ and eggs (Burt, 1932). HERKIMER: *Wilmurt,* Aug. 3, 1902, 16 ads., N. Y. S. M. No. 29 (F. C. Paulmier). JEFFERSON: *Somerville* (Dunn, 1918); M. C. Z. No. 1188(11), 164(14), 165(3), 187(18), 191. LIVINGSTON: *Avon,* Apr. 27, 1929, several spec. (W. Pierson). MADISON: *Cazenovia,* Aug. 1908, 1 ad., N. Y. S. M. No. 101 (I. H. Vrooman). MONROE: *Bushnell basin,* Nov. 20, 1931, 1 ad.; *Fairport* (Wright and Moesel, 1919); *Glen Edith,* May 13, 1933, U. R. No. 3014 (H. Snearing and A. Thurston); *Mendon ponds* (Wright and Moesel, 1919); *Powder Mills* (Wright and Moesel, 1919); April 18, 1937, ads.; *Rochester,* Durand-Eastman Park (Wright and Moesel, 1919); Apr. 19, 1929, 3 spec.; Maplewood Park, Oct. 4, 1928, many, U. R. No. 839; Apr. 24, 1929, 116 ads., 77 juv., U. R. No. 1300, 1303–04, 3393; May 29, 1929, 2 ads., 31 juv. (E. Hilfiker); June 25, 1929, 3 ads. (S. C. B. and R. Hart); Sept. 30, 1929, 24♂, 17♀, 4 juv., U. R. No. 3178, 3392 (H. H. Hood, J. D. Hood and E. Maynard); Oct. 7, 1929, 55♂, 52♀, 25 juv., U. R. No. 3391 (Hood, 1934) Oct. 9, 1929, 14 juv.; Oct. 16, 1929, 40♂, 46♀, 39 juv., U. R. No. 1303, 3389 (Hood, 1934); Oct. 15, 1930, 46 spec., U. R. No. 1193; *Tufa Glen,* Oct. 22, 1930, U. R. No. 1223. NIAGARA: *Niagara Falls,* 1891, 4 spec., U. S. N. M. No. 57024–7, 57097–8 (J. Hurter). ONEIDA: (Cope, 1889); *White lake,* July 1902, 12 spec., N. Y. S. M. No. 35 (E. C. Eckel). ONONDAGA: *Jamesville, Marcellus, Onondaga Hill, Onondaga Valley, Pompey* (H. W. Britcher, 1903); *Syracuse,* May 3, 1920, 6 juv. and ad., R. Sta. 654 (H. R. Hunt); *Branchipus pond,* July 15, 1916, eggs (J. R. Slater); July 26, 1916, 1 ad. (J. R. Slater). ONTARIO: *Canandaigua lake,* Woodville, Aug. 1929, 1 ad.; *Clifton Springs,* Apr. 13, 1920, 1 spec. (J. D. C.); *Naples,* Aug. 21, 1923, sev. ORANGE: *Bear Mountain,* Oct. 20, 1875, common (Mearns, 1898); *Harriman,* 1930 (Burt, 1931); *Highland Falls,* 1 spec., U. S. N. M. No. 23210 (E. A. Mearns); U. S. N. M. No. 23211–12 (E. A. Mearns); *Palisades Interstate Park,* Bear Mountain section, summer 1923, yg., A. M. N. H. No. 24209–10 (G. S. Myers); *Kanohwahke lakes,* July–Aug. 1923, common (G. S. Myers, 1930); *Port Jervis,* (G. Bump). PUTNAM: *Carmel,* May 22, 1926, 2 spec. (S. C. B., H. Hasbrouck, and H. H. Cleaves). QUEENS: *Jamaica,* May 26, 1912, 1 ad., A. M. N. H. No. 3023 (H. Boyle); Mar. 24, 1919, 2 ads., A. M. N. H. No. 6491–2 (H. Boyle); *Long Island City,* Apr. 1914, C. U. RENSSELAER: *Averill Park,* June 17, 1902, 10 spec., N. Y. S. M. No. 54 (F. C. Paulmier); *East Nassau,* June 22, 1922, N. Y. S. M. (S. C. B. and A. Wolf); Aug. 17, 1927, N. Y. S. M.

No. 3944 (S. C. B. and W. J. S.); *Hoosick Falls,* Apr. 11, 1922, 2 ads., N. Y. S. M. No. 9136; *Melrose,* Apr. 25, 1926, 1 spec. (H. H. Cleaves); *Mount Rafinesque,* June 6, 1926, 4 ads., 1 yg., N. Y. S. M. (C. Brown); *Rensselaer,* May 10, 1920, 2 ads., N. Y. S. M. (W. J. S.); Aug. 1, 1920, 3 ads., N. Y. S. M. No. 9119 (W. J. S.); Sept. 1920, 2 ads. (W. J. S.); Apr. 4, 1922, 1 spec., N. Y. S. M. No. 9133; Aug. 11, 1927, N. Y. S. M. No. 3940 (K. F. Chamberlain); *Mill creek,* May 21, 1902, 1 ad., N. Y. S. M. No. 56 (F. C. Paulmier); *Pike pond,* Apr. 17, 1922, 1 spec., N. Y. S. M. No. 9145; *Schodack,* Apr. 22, 1922, 3 ads., N. Y. S. M. No. 9151. RICHMOND: *Staten Island* (Davis, 1884); Apr. 30, 1927, (P. Schiffer); Nov. 26, 1927 (P. Schiffer); *Huguenot,* Nov. 5, 1905, 2 spec. (W. T. Davis); *New Springville,* 1931 (Wilmott, 1933); 12 mi. s.w. of *St. George Ferry,* 1930 (Burt, 1931); Wall st. (Davis, 1923); Woodroe, Apr. 7, 1907, several spec. (W. T. D.) ROCKLAND: Apr. 4–10, 1909, 1 ad., N. Y. S. M. (A. J. Klein); *Orangeburg,* June 7, 1923, 2 spec., A. M. N. H. No. 18,787–92 (G. K. Noble and G. S. Myers); 2 mi. N. of *Rockland lake,* 1930 (Burt, 1931); *Suffern,* Apr. 10, 1920, 1 spec., A. M. N. H. No. 7467 (K. P. Schmidt); *West Haverstraw,* Apr. 12, 1930, 1 juv. (Burt, 1931). ST LAWRENCE: *Cranberry lake,* June 12, 1915, 1 ad., R. Sta., (W. M. B.). SARATOGA: *Saratoga lake,* May 31, 1922, 1 spec., A. M. N. H. No. 16,576 (C. S. Phelps). SCHENECTADY: *Mariaville,* May 5, 1923; *Rotterdam Junction,* May 30, 1927, 2 spec. (H. Eldredge). SENECA: *Junius* (Wright and Moesel, 1919). STEUBEN: *Arkport,* May 14, 1933, 1 spec., U. R. No. 3179 (F. L. Coots); *E. Corning,* June 24, 1937, 1 ad. SUFFOLK: *Cutchogue,* Sept. 14, 1923, 1 ad. (R. Latham); *Gardiner's island,* July 15, 1918, 1 ad. (G. P. Engelhardt); May 25, 1924, 2 spec.; *Laurel,* July 15, 1924, 2 juv. (R. Latham); *Long Island, Baiting hollow,* Apr. 8, 1924, 1 spec., N. Y. S. M. No. 1481 (C. R. Crosby); *Coram,* Aug. 15, 1915, 2 spec. (F. Harper); Apr. 3, 1931, 1 ad.; *Cold Spring Harbor,* Sept. 29, 1924, 4 spec., N. Y. S. M. (A. J. Evans); Jones Pond, *Miller Place,* June 23, 1928, 3 ads. (J. A. Weber); *Montauk,* June 24, 1928, 2 spec. (R. Latham); July 1, 1928, 1 ad. (R. Latham); *Orient,* Sept. 10, 1915 (R. Latham); Apr. 15, 1916, 2 juv. (R. Latham); Dec. 10, 1924 (R. Latham); *Orient Point,* June 24, 1911 (R. Latham); Apr. 3, 1931, 1 ad. (R. Latham); *Peconic,* Mar. 10, 1925 (R. Latham); July 14, 1928, 1 ad. (R. Latham); *Riverhead,* Apr. 11, 1923 (C. R. C.); *Sag Harbor,* May 23, 1932, 2 ads. (R. Latham); *Sound Avenue,* Aug. 20, 1926, 1 spec. (R. Latham); *Southold,* Apr. 20, 1923, 4 ads. (R. Latham); *Wyandanch,* July 8, 1927 (P. Schiffer). SULLIVAN: *Fallsburg* (Dunn, 1918); M. C. Z. No. 1176(4) (S. Lockwood). TIOGA: *Berkshire* (Dunn, 1918); M. C. Z. No. 176, 228, 239(2) (A. Mayor). TOMPKINS: *Besemer* (Reed, 1908); *Willow Point, Cayuga lake,* Sept. 11, 1919, 1 spec. (J. W. Corrington); *Coy Glen,* Apr. 1, 1917, C. U.; Mar. 27, 1920, C. U.; near *Dryden,* May 25, 1924, 1 spec. (F. Harper); *Ellis Hollow,* May 16, 1916, C. U.; *Enfield Glen,* Mar. 4, 1923, C. U.; *Groton,* July 7, 1918, 1 spec. (J. W. Corrington); Apr. 19, 1919 (J. W. Corrington); *Ithaca,* 1904, M. C. Z. No. 3156, 3157, 3159–62, 3164–68, 4659–60 (R. V. Chamberlin); June 1904, 1 ad., M. C. Z. No. 4412 (R. V. Chamberlin); 1906, U. S. N. M. No. 39411–14 (H. D. Reed); Mar. 20, 1913, C. U. (M. D. Leonard); Apr. 14, 1915, C. U., July 10, 1918 (J. W. Corrington); Apr. 9, 1922, 2 spec. (F. Harper); Apr. 28, 1925 (F. Harper); Oct. 17, 1931, several ads. (S. C. B. and E. Maynard); *Cascadilla creek,* Mar. 4, 1922, C. U.; Oct. 11, 1933, 5 spec., U. R. No. 3262 (W. J. Koster); *Cascadilla gorge,* July 26, 1924, 3 spec., N. Y. S. M.; *Cascadilla woods,* Oct. 1, 1924, several (F. Harper); *Cornell campus,* Feb. 24, 1915, C. U.; Apr. 14, 1915, C. U.; *Fall creek,* Mar. 20, 1913, C. U.; Mar. 17, 1921, C. U.; Apr. 21, 1924, several spec. (F. Harper); *Glenside,* Apr. 5, 1919, C. U.; Mar. 29, 1924 (M. D. Pirnie); *Renwick,* Mar. 5, 1910 C. U.; Apr. 14. 1915, C. U.; Apr. 19, 1917, 1 spec. (J. W. Corrington); Apr. 8, 1919, 2 spec. (J. W. Corrington); *Six Mile creek,* Oct. 3, 1909, C. U.; Apr. 13, 1919 (J. W. Corrington); Apr. 25, 1920, 3 spec. (J. W. Corrington); Oct. 10, 1920, 1 spec. (J. W. Corrington); *Larch hill,* May 15, 1919, 3 yg., N. Y. S. M. No. 8606–08 (S. C. B. and A. H. Wright); *Larch meadows,* Oct. 25, 1914

(A. H. Wright); Oct. 25, 1914, C. U.; Apr. 3, 1917, 1 spec. (J. W. Corrington); Apr. 15, 1919, 2 spec. (J. W. Corrington); Oct. 9, 1921 (F. Harper); *Lick brook,* Apr. 11, 1914, 2 spec. (F. Harper); *McLean bogs,* May 27, 1919, 1 ad., N. Y. S. M. No. 8594, (S. C. B. and A. H. Wright); 1922–1925, ads. and eggs (Leffingwell, 1926); July 16, 1924, 1♀ and eggs, N. Y. S. M.; July 1924, several spec. (A. H. Wright); May 3, 1925, 1 spec. (F. Harper); June 2, 1931, ads. eggs (Hamilton); May 2, 1934, 10 ads. and yg., U. R. No. 3395; *Mount Pleasant,* Apr. 13, 1912, C. U.; *Newfield,* Mar. 7, 1921, C. U.; *Ringwood,* May 20, 1919, 1 ad., N. Y. S. M. No. 8605 (H. Dietrich); Apr. 16, 1922, several spec. (F. Harper); *South hill,* Nov. 27, 1921, 1 spec. (F. Harper); *Taughannock,* Oct. 1, 1922, C. U.; *Turkey hill,* Oct. 2, 1921 (F. Harper); Aug. 8, 1923 (S. C. B. and A. H. Wright). ULSTER: *Ashokan,* Aug. 11, 1909, 1 spec., A. M. N. H. No. 2155 (A. L. Treadwell); *Lake Katrine,* Oct. 15, 1906, 5 spec., N. Y. S. M. No. 83–84 (G. L. Chadwick and G. L. Richards); *Saugerties,* Aug. 21, 1911, 2 spec., A. M. N. H. No. 1434–35 (G. von Krockow); *Shokan,* Aug. 18, 1909, several spec., A. M. N. H. No. 2654–64 (A. L. Treadwell); Aug. 18, 1909, 3 ads., A. M. N. H. No. 2665–68 (A. L. Treadwell); summit *Sam's Point,* May 24, 1920, 3 ads., N. Y. S. M. No. 2255; summit *Slide Mountain,* June 20, 1926, N. Y. S. M. No. 3165 (H. H. Cleaves). WARREN: *Adirondack,* U. S. N. M. No. 3807 (Cope, 1889). WASHINGTON: *Bump's pond,* July 28, 1920, 1 spec., N. Y. S. M. No. 9119. WAYNE: *Blind Sodus bay,* Apr. 23, 1933, many spec.; *North Rose,* C. U.; (A. C. Weed). WESTCHESTER: *Grassy Sprain reservoir,* June 11, 1930 (Burt, 1931); *Mount Vernon,* Nov. 30, 1906, 2 ads., A. M. N. H. No. 2186–87 (McVicar); *New Rochelle,* Apr. 30, 1937, 9 ads. (M. Blatchley); *White Plains* (Deckert, 1914); *Yonkers,* Apr. 20, 1919, A. M. N. H. No. 6397–6402 (G. K. Noble and K. P. Schmidt); Nov. 4, 1928, 1 spec. (G. K. Noble and J. A. Weber). WYOMING: *Letchworth Park,* May 18, 1932, 3 spec., U. R. No. 2480; *Strykersville,* Oct. 7, 1928, 1 ad. (F. J. Holl).

Records too indefinite to be placed under counties. *New York,* (DeKay, 1842; Boulenger, 1882; Cope, 1889; Yarrow, 1882; Eckel and Paulmier, 1902; Ditmars, 1905); 1 spec., U. S. N. M. No. 4891 (J. Stauffer); *Catskill mountains,* 1880–1882, several (Bicknell, 1882); *Cayuga Lake basin* (Reed and Wright, 1909); Mar. 25, 1914, C. U.; 1925–1932 (Hamilton, 1932); *Hudson Highlands* (Mearns, 1898); *Long Island,* 1880, ads., A. M. N. H. No. 2122–25 (N. Pike); 1882, A. M. N. H. No. 2146–47, 2126–39, 2141, 2144 (N. Pike); Oct. 7, 1885, A. M. N. H. No. 2145 (N. Pike); Aug. 10, 1889, A. M. N. H. No. 2143 (N. Pike); Apr. 22, 1917, 1 spec., A. M. N. H. No. 2456 (A. Field); *Northern New York,* (Baird, 1850).

Condensed Bibliography

Life history and habits. Abbott, 1884, p. 343 (red-backed salamander); Baird, 1850, p. 285 (*Plethodon erythronota*); Barbour, 1914 (*Plethodon erythronotum*); Bishop, 1925, p. 10 (*Plethodon cinereus*); Bishop, 1927, p. 46–48; Blanchard, 1928, p. 156–64 (*Plethodon cinereus cinereus*); Burt, 1932, p. 76 (*Plethodon cinereus*); Burger, 1935, p. 578–86; Cochran, 1911, p. 332–49 (*Plethodon cinereus erythronotus*); Cope, 1889, p. 134 (*Plethodon cinereus cinereus*); Ditmars, 1905, p. 171 (*Plethodon cinereus erythronotus*); Dunn, 1926, p. 163–80 (*Plethodon cinereus*); Hamilton, 1932, p. 85; Montgomery, 1901, p. 503–08; Murphy, 1917, p. 105; Murphy, 1918, p. 8; Noble and Weber, 1929, p. 5; Noble and Brady, 1930, p. 53; Piersol, 1910*a*, p. 469–93 (*Plethodon cinereus erythronotus*); Piersol, 1914, p. 121–26 (*Plethodon cinereus*); Putnam, 1865, p. 173 (*Plethodon erythronotus*); Reed, 1908, p. 460–64 (*Plethodon cinereus*); Reed and Wright, 1909, p. 403 (*Plethodon erythronotus*); Sherwood, 1895, p. 3–32 (*Plethodon cinereus cinereus*); Smallwood, 1928, p. 91; Surface, 1913, p. 93–95 (*Plethodon cinereus*).

Distribution in New York. Baird, 1850, p. 285 (*Plethodon erythronota*); Baird, 1852, p. 21 (*Plethodon cinereus* and *P. erythronota*); Bicknell, 1882,

p. 124 (*Plethodon erythronotus*); Bishop, 1923, p. 66 (*Plethodon cinereus*); Bishop, 1927, p. 48; Boulenger, 1882, p. 57 (*Plethodon erythronotus*); Britcher, 1903, p. 120 (*Plethodon cinereus* var. *cinereus; P. c. erythronota*); Burt, 1931, p. 199 (*Plethodon cinereus*); Burt, 1932, p. 76; Cope, 1889, p. 137 (*Plethodon cinereus cinereus; P. c. erythronotus*); Davis, 1884, p. 13 (*Plethodon erythronotus*); Deckert, 1914 (*Plethodon cinereus*); DeKay, 1842, p. 75 (*Salamandra erythronota*); Ditmars, 1905, p. 170–71 (*Plethodon cinereus; P. c. erythronotus*); Dunn, 1918, p. 462 (*Plethodon cinereus*); Eckel and *Paulmier,* 1902, p. 400; Eights, 1836, p. 130 (*Salamandra erythronota*); Hamilton, 1932, p. 85 (*Plethodon cinereus*); Hood, 1934, p. 141; Leffingwell, 1926, p. 72; Mearns, 1898, p. 323 (*Plethodon cinereus; P. erythronotus*); Myers, 1930, p. 100 (*Plethodon cinereus*); Noble, 1927, p. 2; Noble and Weber, 1929, p. 5; Reed, 1908, p. 460; Reed and Wright, 1909, p. 403 (*Plethodon erythronotus*); Sherwood, 1895, p. 31 (*Plethodon cinereus cinereus; P. c. erythronotus*); Smallwood, 1928, p. 91 (*Plethodon cinereus cinereus*); Smith, 1882, p. 724 (*Plethodon erythronotus*); Weber, 1928, p. 108 (*Plethodon cinereus*); Wilmott, 1933, p. 163; Wright and Moesel, 1919, p. 64; Yarrow, 1882, p. 154 (*Plethodon cinereus erythronotus*); 7th Ann. Rep't State Cab. Nat. Hist. 1854, p. 25 (*Plethodon erythronotus*); 61st Ann. Rep't N. Y. State Mus. 1908, p. 132 (*Plethodon cinereus erythronotus*); 62d Ann. Rep't N. Y. State Mus. 1909, p. 99–100 (*Plethodon cinereus; P. c. erythronotus*); 72d Ann. Rept. N. Y. State Mus. 1919, p. 94 (*Plethodon cinereus*); Proc. Staten Island Inst. Arts and Sci. 1931, 6(1): 42.

General. Allen, 1869, p. 198 (*Plethodon erythronotus*); Cope, 1885, p. 313 (*Plethodon cinereus*); Cox, 1898, p. 64; Holbrook, 1842, p. 43 (*Salamandra erythronota*); Hurter, 1911, p. 81 (*Plethodon erythronotus*).

PLETHODON GLUTINOSUS (Green)

(*Salamandra glutinosa,* Jour. Acad. Nat. Sci. Phila., 1818 1(2): 357)

Slimy Salamander

Figures *2i*, *4i*, *40a–b*, *42–44*

The slimy salamander was described in 1818 but the details of its life history and habits in the North still remain unknown.

It is one of the strikingly marked salamanders with bright silvery white markings on a black ground.

Description

Size. The sexually mature individuals from New York localities I have measured, varied in length from 105 to 168 mm in the females, and from 121 to 188 mm in the males. A series of fifteen adults of both sexes, taken at the head of Canandaigua lake, N. Y., August 23, 1923, varied from 110 to 188 mm and averaged 144.3 mm. The ten largest specimens in this series averaged 163.4 mm and the extremes were 152 and 188 mm.

Ten adult males from various localities in western New York but not including the series from Canandaigua lake, varied in length from 120 to 170 mm and averaged 147.3 mm. A similar series of females varied from 105 to 168 mm and averaged 143.6 mm.

In the male the tail may comprise from 50.3 to 53.5 per cent of the total length and in the females the variation is from 47.6 to 52.7. In both sexes, the tail is proportionally shorter in the juveniles than in the adults.

Form. The body of the slimy salamander is well rounded and proportioned. In some species, such as *P. cinereus,* the tail seems disproportionally long and the legs too small but in *P. glutinosus* the various parts are properly balanced and the animal has a decidedly sleek appearance and an alertness uncommon among members of its kind.

The head is moderately broad, widest just behind the eyes, slightly narrowing behind to the lateral extensions of the gular fold and rather abruptly tapering to the truncated snout.

The eyes are prominent with the upper lid fitting over a thin, flangelike flap on the lower lid anteriorly. The mouth is moderately large with the angle of the opening back of the posterior corner of the eye. The commissure of the jaws forms a gently arched line. The gular fold is well developed, but not overlapping and is continued on the sides of the neck. Posteriorly from the eye there is an impressed, sinuous line that curves down sharply behind to join the extension of the gular fold. From this horizontal line there is a short groove passing downward back of the angle of the jaw.

The legs are well developed and muscular and can carry the body clear of the ground. The toes of the fore feet are rather short, wide, slightly webbed at base, and bluntly tipped, 1-4-2-3 in order of length, the second and fourth almost equal. The hind legs are longer, larger and stronger, the five toes longer but not more slender than those of the fore feet. The toes in order of length, 1-5-2-3-4, 3-4 about equal. There are 16 costal grooves counting one each in the axilla and groin. In the male there are from 2 to 3½ costal folds between the appressed toes.

The tail is nearly round in cross section near the base but may be slightly flattened above and below. It gradually tapers, in uninjured individuals, to a slender point.

This salamander derives its common name from the abundance of sticky slime produced when stimulated; but in preserved specimens, the openings of the glands are not so conspicuous as in many other species. They are largest and most abundant on the dorsal surface of the tail.

The vomerine series is long and the teeth which number 12 or 13 form rather irregular lines. The series start well outside the opening

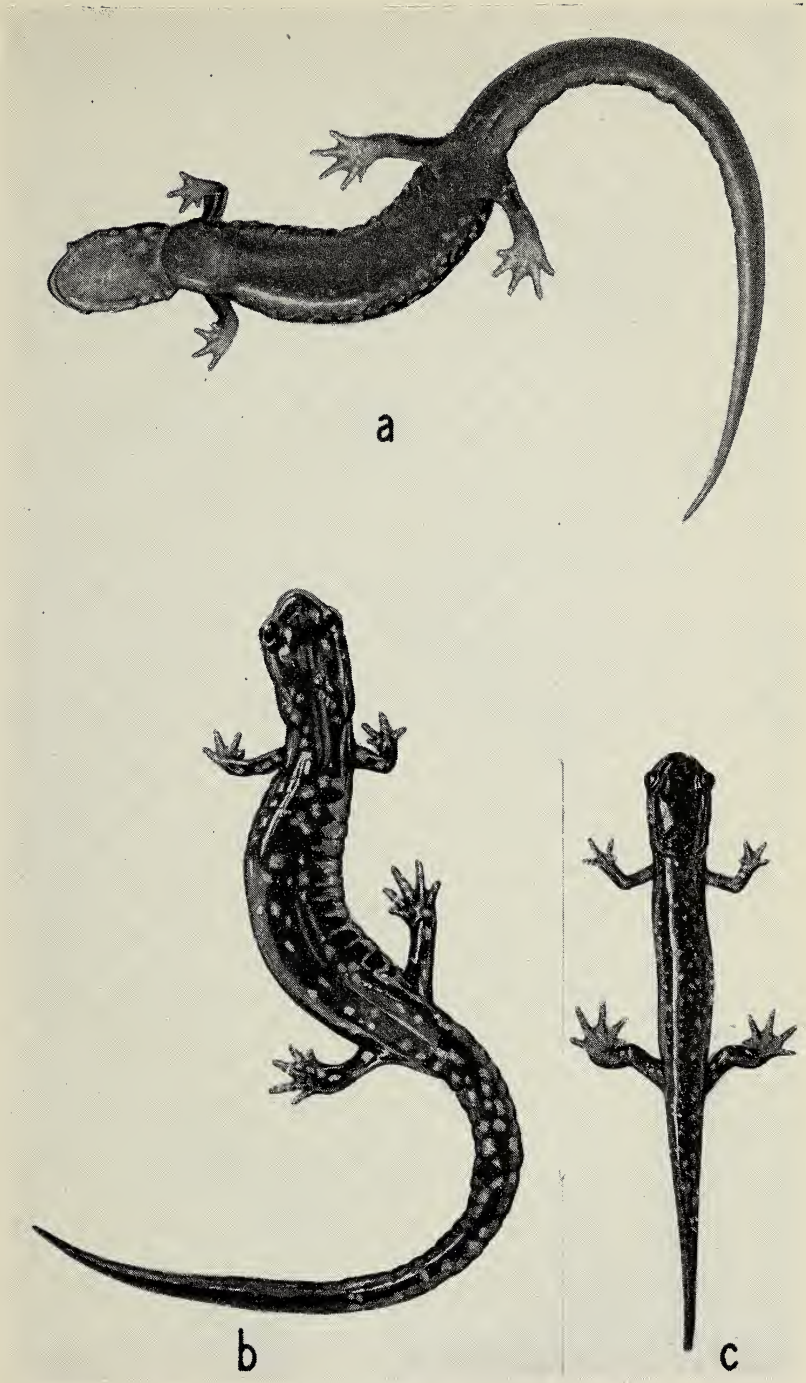


Fig. 42 *Plethodon glutinosus*. a. Adult female, ventral view, Ithaca, N. Y., Oct. 11, 1933. Actual length 163 mm. H. P. C., del. b. Adult female, dorsal view, Woodville, Canandaigua lake, N. Y., Aug. 23, 1923. S. C. B., del. c. Juvenile, X 2, Albany, N. Y., Oct. 1922. E. K. O'B., del.

Fig. 43 Upper, *Plethodon glutinosus*. A typically marked specimen from Woodville, Canandaigua lake, N. Y. Note absence of spots on distal third of tail. Slightly less than natural size. Lower, A roadside shale bank near the head of Canandaigua lake. Typical habitat of *Plethodon glutinosus*. Following a rain, the salamanders appear in great numbers from crevices in the shale and forage over the steep bank.

of the inner nares, extend inward and backward to a point opposite the posterior angle of the eye and are separated from each other and the parasphenoid by a distance equal to one-half the length of one series. The parasphenoid teeth usually form two, long, narrow patches with the sides nearly straight, and ends rounded, not club-shaped as in many species. They are narrowly separated at best and sometimes unite to form a single large patch.

The tongue is broad and flat and fills the floor of the mouth. It is free only at the sides and narrowly behind. The plicae converge at a median groove posteriorly.

Color. The general ground color is black or blue-black with the soles of the feet flesh-colored in life and fading to dull white in preservative. The belly is usually a little lighter, greenish slate, with tinges of red in the region over the heart, and with slightly mottled throat and lighter gular fold. In most adult specimens in the North, the distal third of the tail is dull grayish brown and usually free from lighter markings. Scattered generally over the sides of the head, trunk and tail, and often over the entire dorsal surface except the end of the snout and tail, are many silvery white spots variable in size and shape but usually largest on the middle of the sides. In some individuals, the spots may be almost absent above or greatly reduced in size and number.

I have specimens from Columbia, S. C., received from Dr J. D. Corrington, on which the white spots are almost lacking and in another series from Rankin county, Miss., received from W. W. Winstead, the light spots on the lower sides are so large and numerous that they form a broad, fairly regular, white band.

An albino specimen of this species is reported from Monroe county, Indiana, by Piatt (1931, p. 29). In this the venter is said to be without pigment while the dorsal surfaces are sprinkled with grayish.

Sexual differences. In mature males and those approaching maturity there is a well-developed mental gland that appears as a circular, light spot just back of the anterior margin of the lower jaw. The vent of the male is lined with papillae and the snout, in side view, seems to be a little more abruptly truncated than in the female. I have been unable to discern any striking differences in the arrangement or size of the teeth. In the males, the tail usually equals or slightly exceeds the length of the head and trunk while in the females it is frequently shorter. The differences are too slight, however, to be reliable as an index to sex.

Activities of the Breeding Season

Very little is known of the breeding habits of this species. On August 17, 1928, B. C. Marshall found the eggs of this species in Sheridan cave near Mountain Home, Ark., and on September 3d a second batch in Indian cave near Bella Vista, Ark. This discovery was reported by Noble and Marshall. (1929, p. 6.)

Nothing is known of the mating habits, spermatophores or egg laying under natural conditions in the North.[1] By the dissection of a considerable number of individuals it has been possible to determine that the egg-laying season does not coincide with that of the species in the Ozarks and many observations in the field indicate that a different situation is chosen for desposition of the eggs.

Dissections of males indicate that the mating season is in the fall. Males from Rochester and Ithaca, N. Y., taken in October had the vas deferens swollen and packed with sperm. In specimens taken May, June, July and August the vas deferens is small and string-like and without evidence of sperm.

In all large females taken in the fall and winter months, from September through December, the ovarian eggs have varied from 1–2 mm to 3½ mm in diameter. I have found no large eggs in females taken in May and through the summer months. This would indicate that the eggs are deposited after December and usually sometime before May, scant information, perhaps, but sufficient to indicate that in the northern parts of its range, the time of egg laying differs from that in the Ozarks.

In their account of the courtship of some plethodontid salamanders Noble and Brady (1930, p. 53) include *P. glutinosus* and indicate that the general pattern is essentially the same among the several species observed. "In all species, so far as determined, there is a series of preliminary rubbing movements during which the male applies his lips, cheeks, mental gland, or side of body to the snout of the female. This arouses the female's interest in the male. In the second phase of the courtship, the female follows the male, keeping her chin pressed closely against his tail base as they move about the tank. The male, especially when he is not moving forward, undulates the base of his tail from side to side."

The egg mass. The eggs discovered by Marshall:

Were hanging suspended from a perpendicular wall forming the back of a pocket in the cave wall about four feet above the floor

[1] Fowler (Copeia, No. 2, p. 133, 1940), has reported the discovery of a female coiled around about 15 eggs, at Ice Mountain, W. Va., June 3, 1938.

of the cave. The pocket was approximately eight inches long by six inches high and six inches deep. It was near the entrance of the cave. The eggs which were in the cleavage stages were accompanied by a large female, 162 mm. in total length and 75 mm. head and body length. The female was resting on the floor of the pocket under the eggs. . . .

On September 3, of the same year, an additional set of eggs of *P. glutinosus* was found. These were discovered in Indian Cave, near Bella Vista, Arkansas. They were lying in the bottom of a small crevice in the wall of the cave about three feet above the floor and two hundred feet from the entrance of the cave. The eggs contained well developed embryos. No adult was found with them but two immature *P. glutinosus* were found in other parts of the cave. . . .

There are eighteen eggs in the first bunch collected and only ten in the second. The eggs are not stalked but held together in a single gelatinous envelope. This common envelope is clearly shown in both bunches of eggs but particularly in the earlier set where the eggs have been little damaged in transportation. (Noble and Marshall, 1929, p. 6.)

Large ovarian eggs in the females dissected varied in number from 17 to 38. A female only 155 mm long had 21 eggs in the right ovary and 15 in the left. A female 168 mm long had a total of 38 eggs, both specimens taken in September. In a specimen taken in December there were seven eggs in the right ovary and ten in the left. The smaller number agrees closely with the 18 eggs found in the Ozarks by Marshall and may indicate that some of the eggs developed early in the season are later reabsorbed.

Development

The egg and its envelops. Noble and Marshall (*ibid.*, p. 7) have indicated that, except for the absence of a stalk, the eggs of *P. glutinosus* agree closely with those of *P. cinereus*.

There is a thin adherent vitelline membrane, and a rather thick egg-capsule surrounding it. This egg-capsule may be divided into several layers. In the earlier and better preserved eggs it is divided into an inner and an outer capsule, the latter not as thick as the former. In the older and in some of the younger eggs the inner of these two capsules may be divided again into several layers.

An average egg of *P. glutinosus* measures 5.5 mm in diameter. It is creamy white in color. Its vitelline membrane measures only a fraction of a millimeter more than the diameter of the egg. The inner of the two surrounding egg-capsules measures 6 mm in diameter, the outer 6.5 mm. The common envelop or outer sphere of Piersol measures 7.5 mm in diameter in this egg but it is somewhat variable in thickness about the other eggs.

The eggs of *P. glutinosus,* with an average diameter of 5.5 mm, are exceeded in size only by the largest eggs of the mudpuppy, *Necturus maculosus,* among all the salamanders found in the State. The abundance of yolk in the egg and developing embryos is correlated, of course, with the terrestrial development of the young.

Nothing is known of the length of the period of incubation, the size of the newly hatched larvae or the length of the larval period. Embryos which were well developed and perhaps near the point of hatching measured 16 mm in total length. Noble and Marshall describe the embryos as follows:

> The antler-like gills are joined at their bases. The embryos are well pigmented above with stellate melanophores. These are most numerous along the sides of the body. A narrow vertebral line and a number of small spots scattered over head and back are for the most part devoid of pigment. A great many of the melanophores on either side of the pigmentless vertebral line have their processes extended transversely to the axis of the body, while on other parts of the embryo they exhibit an irregular radiate form. This suggests that these dorsal melanophores are migrating towards the sides of the body where the pigmentation is already greatest. Further, there would seem to be some mechanical obstruction underlying the epidermis to prevent their reaching the midline of the body or sending their processes across the small white spots.

In other words, the embryo of *P. glutinosus* differs in no essential respect from an embryo of *P. cinereus* of the same stage of development, even to the presence of a dorsal stripe.

Development to maturity. I have not collected or measured a sufficient number of individuals from the same locality and taken at essentially the same time of the year, to give a clear indication of the rate of growth to maturity.

I have measured small specimens, very evidently the young of the year, that were only 30 to 34 mm in total length. The records of these specimens are as follows:

Ithaca, N. Y. ..... July 10, 1924, 34 mm total length
Ithaca, N. Y. ..... July 15, 1924, 31 mm total length
Portland Point, N. Y. ..... July 19, 1924, 30 mm total length

The size of these individuals, collected in July, lend some support to the view that the eggs hatch very early in the year. My own dissections indicate that the females had deposited their eggs before May but J. R. Slater recorded (in mss. thesis) that a female taken May 4th had 23 large eggs in the ovaries, so it is possible that the season may be extended to include the first week or two in that month.

The smaller of the young salamanders collected lacked the light spots but on the 34 mm individual the silvery white flecks were conspicuous.

In a series of 22 specimens of various sizes taken in western New York during October and November it is evident that several age groups are represented but the number collected is insufficient to give more than a general estimate of the growth rate. A group of four juveniles varied in length from 58 to 64 mm and perhaps represent the growth to the end of the first season. Another lot of eight varied from 74 to 98 mm. The remaining specimens in the series included sexually mature individuals up to 170 mm in length and some females approaching maturity at a length of 105 to 110 mm.

Habits

General. This species is terrestrial and nocturnal in its habits. While it is not particularly active unless disturbed, it possesses an alertness that distinguishes it from the majority of salamanders. Its usual gate is a deliberate crawl but it is capable of rapid movements and aided by its slippery skin, often escapes capture.

Unlike its smaller relative, *P. cinereus*, the slimy salamander is not much given to burrowing and although frequently found well below the surface of the ground, it is evident that cracks or crevices have been followed.

To gain some idea of the great number of individuals that may be present in a suitable locality, one should visit a wooded hillside or shale bank at night during the first fall of rain following a period of drouth. Under these circumstances, they are sometimes to be found in large numbers, crawling over the surface of the ground or resting with the head exposed at the opening of a crevice or from beneath the edge of a stone.

Food. Surface (1913, p. 97) examined 170 specimens, from various localities in Pennsylvania, of which the stomachs of 125 contained food. "This consisted of earthworms, snails, spiders, thousand-legged worms, and insects and their larvae."

Hamilton (1932, p. 85), employing the percentage by bulk method, presented the following:

Sixty-four stomachs were studied. Insects constitute 48.8; sowbugs, 16.2; annelids, 11.4; centipedes, 11; spiders, 5.7; slugs, 2.4; snails, 1.6, and extraneous matter, 3 per cent of the food. About half of the food consisted of insects. Ants, beetles (principally weevils, chrysomelids, lampyrids and small staphylinids), jassids, and a few miscellaneous forms make up this class. Centipedes,

while forming only a little more than ten per cent of the food in bulk, were found in over half the animals examined. These chilipods, notably the small forms, seem to be a favorite and readily secured item of food for all terrestrial salamanders.

A number of writers have mentioned a few items in the diet of this species but add nothing to the accounts quoted above.

In view of the statement by Noble (1931, p. 84) that *Plethodon cinereus* and *P. glutinosus* "are of very different sizes and hence would not compete for the same food," it is of interest to compare the records obtained by Hamilton (1932, p. 85). Hamilton found that insects constituted 57 per cent of the food eaten by *P. cinereus* and 48.8 per cent of the food of *P. glutinosus*. Ants, beetles, spiders, sowbugs, mollusks and worms were taken by both. Surface (1913, p. 95, 97) found that both species had taken snails, earthworms, spiders, centipedes and insect larvae and adults.

Habitat

The slimy salamander is commonly found beneath logs and stones in woods, in the crevices of shale banks and along the sides of gullies and ravines. Often it is to be found under moist humus and leaf mold or in manure piles. I have taken many specimens in situations that provided but little moisture on the surface of the ground and others where the ground was constantly moist. In extremely dry seasons, the species sometimes disappears altogether from its usual haunts and may be found only by digging deeply into the soil or following the crevices that extend far into banks.

While the red-backed salamander is often found in situations that are suitable for *P. glutinosus,* the latter species is much more localized. In any piece of woodland where *P. cinereus* may be found under almost every suitable piece of cover, the slimy salamander, if present, is usually restricted to a limited area. Its requirements are difficult to determine. It is certainly more susceptible to changes in humidity than *P. cinereus* and disappears from the surface much more promptly in times of drouth. These observations are in accord with those of Shelford (1913, p. 106) who noted that *P. glutinosus* is much more sensitive to dry air than *P. cinereus.*

I have found the species most abundant in shale banks bordering highways and clearings in woods. During the day they may be entirely absent but after dark, particularly if a rain has fallen, they appear from their retreats beneath the surface and forage over the ground. Coming from the deep recesses the salamanders rest for

a time at the openings in the shale, their heads alone exposed. If disturbed they back quickly out of sight.

The depth to which the salamanders will retreat is limited only by the extent of the crevices in the shale and rocks. At the head of Canandaigua lake, the operations of a steam shovel in road construction presented the opportunity to determine that the salamanders were often tumbled from their homes four or five feet deep in the shale.

I have dug the slimy salamander from its winter retreat far below the surface and the females recovered in December were well distended with eggs. In the early summer, the young are to be found under loose materials at the surface and it is thus reasonable to suppose that the eggs are deposited in the cavities occupied by the adults.

Remarks

Cope (1889, p. 141) and Dunn (1926, p. 139) record young specimens from Virginia and Georgia as having red spots on the sides or back. I have never observed red-spotted specimens in the North but only a few young have been collected and it is of course possible that the spots are not developed on all individuals.

Eggs or embryos, supposedly of this species, were reported by Okey (1916, p. 25) but as Noble and Marshall (1929, p. 6) have pointed out, the material probably represented *Ambystoma microstomum (= texanum)*.

This species has often been confused with *Ambystoma jeffersonianum* but the resemblance is limited to a similarity in color and general sliminess. *P. glutinosus* is black or blue-black with silvery white flecks. *A. jeffersonianum* when half-grown may be very dark but the spots are pale blue and with age the general ground color becomes brown and the light spots fade. The round tail of the former and the strongly compressed tail of the latter should immediately distinguish them.

The slimy salamander has as its near relatives, *P. wehrlei* and *P. yonahlossee,* as indicated by Dunn (1926, p. 140). To this group may be added *P. ouachitae.*

Smith (1882, p. 726) reported the slimy salamander as hibernating under wet logs and resorting to the water to breed in April. It is evident that some other species was under observation, probably an ambystomid.

DeKay's (1842, p. 81) description of *Salamandra glutinosa* applies as well to *Ambystoma jeffersonianum* as to the slimy salamander.

He mentions particularly the "small irregular bluish white spots," which are always present in the young Jefferson salamander and only slightly developed in the young specimens of the slimy. He figures a small specimen (pl. 17, fig. 42) with long, slender, tapering toes which is characteristic of *A. jeffersonianum.* The only character mentioned that would apply better to the slimy salamander than to *A. jeffersonianum,* is the rounded tail.

The species described by DeKay *(ibid.,* p. 85) as *Triton porphyriticus* is, without doubt, the slimy salamander.

Range

"Southern New York to Wisconsin, south to northern Florida, the Gulf States to Texas and to Missouri" (Stejneger and Barbour, 1933, p. 11), except as modified below under account of distribution in New York.

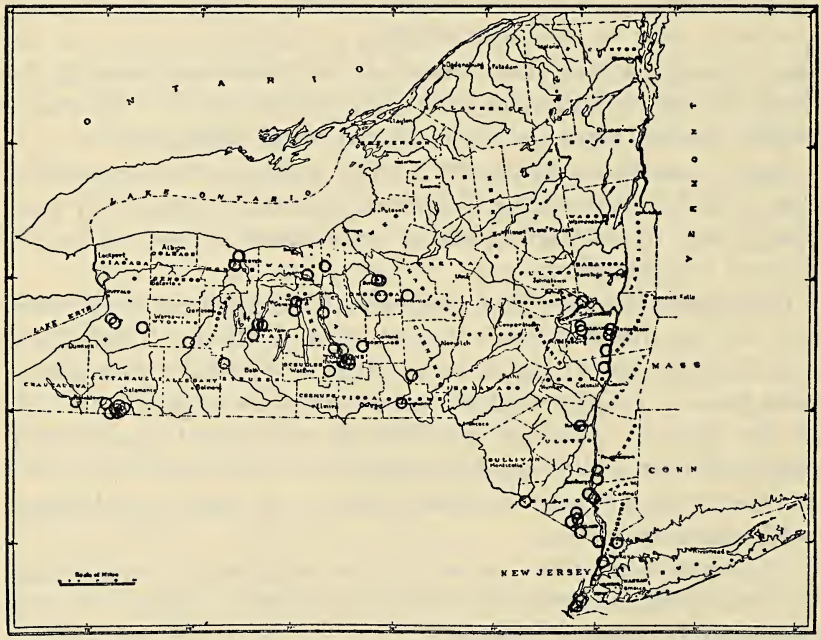


Fig. 44 New York localities for *Plethodon glutinosus.*

Distribution in New York

General. Throughout the State except in the higher mountains and on Long Island.

Specific records. ALBANY: *Albany,* (25th Ann. Rep't State Cab. Nat. Hist. 1873); *Altamont,* June 25, 1902, N. Y. S. M. No. 43 (F. C. Paulmier); *Kenwood,* Oct. 3, 1901, 1 ad., N. Y. S. M. No. 16 (Bishop, 1923); *Selkirk,*

June 3, 1924, 1 spec., N. Y. S. M. No. 1575 (W. Peltz and J. Easton); Sept. 15, 1924, 1 spec. (S. C. B., W. Peltz, and J. Easton); *Thacher Park,* Indian Ladder, May 13, 1904, 1 ad., N. Y. S. M. No. 72 (Bishop, 1923). BRONX: *Van Courtland Park,* 1890, 1 ad., A. M. N. H. No. 2696 (E. F. Southwick). BROOME: *Binghamton* (G. Bump). CATTARAUGUS: *Allegany State Park,* Bear Caves, May 15, 1937, 1 juv. (Van Auken); Blacksnake Mt., July 10, 1931, 1 ad., (Homer Jack); Coon run, Aug. 3, 1922, 4 ads. (Bishop, 1927); English run, Aug. 16, 1922, 1 ad., R. S. No. 4445 (W. A. Dence); near Halls, Red House valley, Aug. 12, 1923, 5 ads., (Bishop, 1927); Natural history school, July 1927, 1 ad. (R. C. Coker); Aug. 24, 1937, 1 juv.; Oct. 15, 1928, sev. juv.; Seneca mountain, Aug. 24, 1926, 1 ad., N. Y. S. M. No. 3101, (Bishop, 1927); Slide hollow, July 29, 1921, 3 ads., (Bishop, 1927); Stony run, Aug. 19, 1926, 2 ads. (Bishop, 1927); Willis hollow, July 7, 1922, 1 ad., N. Y. S. M. No. 3330 (Bishop, 1927); hillside between Willis run and Coon run, Aug. 10, 1926, 2 ads., N. Y. S. M. No. 3176–77 (Bishop, 1927); *Tunasasa,* Quaker School, Aug. 3, 1922, several ads. (Bishop, 1927); near river, Aug. 19, 1926, 2 ads. (Bishop, 1927). CAYUGA: *Aurora,* Paines creek, Apr. 20, 1924, C. U. (D. D. L.); *Duck lake* (Wright and Moesel, 1919). CHAUTAUQUA: *Poland Center,* Sept. 12, 1937, 1 juv. CHENANGO: *Greene,* 1 juv., Aug. 1922 (L. Bartlett); Oct. 5, 1923, 1 ad., N. Y. S. M. No. 9545 (E. Bartlett). DUTCHESS: *Fishkill,* Sept. 28, 1904, N. Y. S. M. No. 73 (F. C. Paulmier); *Wappinger Falls,* May 27, 1920, 1 ad., N. Y. S. M. No. 9113. ERIE: *Boston, Hamburg, Holland,* Apr.–Oct. 1925 (R. R. Humphrey). GREENE: *Coxsackie,* 1851 (5th Ann. Rep't State Cab. Nat. Hist., 1852). MADISON: *Cazenovia,* A. N. S. (Fowler and Dunn, 1917). MONROE: *Mendon ponds,* Nov. 1, 1931, U. R. No. 2153 (K. Lagler); *Rochester,* Durand-Eastman Park (Wright and Moesel, 1919); Maplewood Park, Oct. 4, 1928, several ads., U. R. No. 786; May 29, 1929, 2 spec. U. R. No. 3264–65 (E. Hilfiker); June 25, 1929 (S. C. B. and R. Hart); Sept. 30, 1929, 2 spec., U. R. No. 3176 (Hood, Maynard and Hincher); Oct. 5, 1929, U. R. No. 2166–67 (J. D. Hood and B. Widiker); Oct. 7, 1929, 3 spec., U. R. No. 3177 (Hood, Maynard and Hincher). ONONDAGA: near *Branchipus pond,* May 4, ♀s and yg. (J. R. Slater); June 19, ads. and yg. (J. R. Slater); *Onondaga reservation* (Britcher, 1903); *Syracuse,* S. Salina st., Oct. 14, 1 ad., R. S. No. 308. ONTARIO: *Canandaigua lake,* Woodville, Oct. 12, 1930, 10 ads.; July 13, 1935, 1 ad.; *Geneva,* Hobart College; *Kashond creek,* May 20, 1932, 1 yg., Hobart College (T. T. Odell); near *Naples,* Aug. 4, 1923, 2 spec., N. Y. S. M. No. 9524 (S. C. B. and A. S. B.); Aug. 5, 1923, 3 spec., N. Y. S. M.; Aug. 21, 1923, 24 spec., N. Y. S. M. (S. C. B. and E. White); Aug. 23, 1923, 20 spec., N. Y. S. M. No. 9523. ORANGE: *Arden,* May 24, 1924, 2 ads., 1 yg., A. M. N. H. No. 21,047–9 (W. G. Hassler); *Highland Falls,* Oct. 9, 1875, 1 ad., A. M. N. H. No. 2698 (E. A. Mearns); *Mountainville,* June 13, 1920, 1 ad., A. M. N. H. No. 12,864 (G. K. Noble and C. L. Camp); *Palisades Interstate Park,* Car pond, July 11, 1919, 1 ad., R. S. No. 2288 (J. P. Moore); *Kanohwahke lakes,* July–Aug. 1923, 1 ad., 3 yg., A. M. N. H. No. 24,211–14 (G. S. Myers, 1930); *Port Jervis,* June 23, 1935 (Bailey). RICHMOND: *Staten Island* (Davis, 1884; Davis, 1908); Clove valley (Wilmott, 1933). ROCKLAND: *Orangeburg,* June 15, 1911, 1 ad., 1 yg., A. M. N. H. No. 1699–1700 (G. von Krockow); June 7, 1923, 1 yg., A. M. N. H. No. 18,786 (G. K. Noble and G. S. Meyers); *Suffern,* July 22, 1905; 2 spec. (Davis, 1908); July 23, 1905, 1 ad., A. M. N. H. No. 2319 (Davis, 1908). SCHENECTADY: *Rotterdam Junction,* May 30, 1927 (H. Eldredge). STEUBEN: *Arkport,* May 14, 1933, 2 ads., U. R. No. 3174 (F. L. Coots). TOMPKINS: *Enfield gorge,* C. U. (R. R. Humphrey); *Ithaca,* July 18, 1906, 1 spec., U. S. N. M. No. 39406 (H. D. Reed); M. C. Z. No. 4412 (Dunn, 1918); July 19, 1923, 2 spec., N. Y. S. M. No. 9521 (A. H. Wright); July 10, 1924, 1 spec. (W. J. S.); July 15, 1924, 2 spec.; July 26, 1924, 6 spec., N. Y. S. M. Ac. No. 1578 (S. C. B., A. Wolf, and W. J. S.); Bool's backwater, C. U., (R. R. Humphrey); Cascadilla creek, Apr. 26, 1914, C. U.; July 10, 1919, 1 spec. (J. D. Corrington); Apr. 25, 1923, C. U.; Aug. 8, 1923, 1 ad. (S. C. B. and A. H. W.); Oct. 17, 1931,

2♂, 1♀, U. R. No. 2125–27 (S. C. B. and E. A. Maynard); Oct. 11, 1933, 3 spec., U. R. No. 3175, 3263 (W. J. Koster); Cascadilla woods, Oct. 1, 1924, 1 spec. (F. Harper); Fall creek, Apr. 22, 1910, C. U.; Apr. 23, 1910, C. U.; Apr. 17, 1916, C. U.; Apr. 6, 1922, C. U.; Forest home, Oct. 20, 1924, 1 spec., C. U. (F. Harper); *McLean,* June 3, 1916, C. U.; *Portland Point,* July 19, 1924, 1 ad., 2 larvae, C. U. (A. H. Wright); *Taughannock gorge,* Oct. 1, 1922, C. U. ULSTER: *Esopus creek,* June 15, 1911, A. M. N. H. No. 1433 (G. von Krockow). WAYNE: (Allen, 1869); *Clyde* (Wright and Moesel, 1919). WESTCHESTER: *White Plains* (Deckert, 1914). WYOMING: *Letchworth park,* May 18, 1932, 1 ad., U. R. No. 2481; June 11, 1933, 1 ad. YATES: *Canandaigua lake, Oak ridge,* Aug. 15–19, 1919, 1 spec., N. Y. S. M. No. 8647.

Records too indefinite to be placed under counties: *New York,* (DeKay, 1842; Baird, 1850; Allen, 1869; Yarrow, 1882; Cope, 1889); general and common (Ditmars, 1905); common in *Cayuga Lake basin,* (Reed and Wright, 1909); 1925–32 (Hamilton, 1932); common in region of the *Hudson Highlands* (Mearns, 1898).

Condensed Bibliography

Life history and habits. Bishop, 1927, p. 48 (*Plethodon glutinosus*); Dunn, 1926, p. 139; Hamilton, 1932, p. 85; Noble and Marshall, 1929, p. 6; Noble and Brady, 1930, p. 53; Surface, 1913, p. 97.

Distribution in New York. Allen, 1869, p. 199 (*Plethodon glutinosus*); Baird, 1850, p. 285; Baird, 1852, p. 21; Bishop, 1923, p. 66; Bishop, 1927, p. 49; Britcher, 1903, p. 120; Burt, 1931, p. 200; Cope, 1889, p. 142; Davis, 1884, p. 13; Davis, 1908, p. 48; Deckert, 1914; DeKay, 1842, p. 81, 85 (*Salamandra glutinosa, Triton porphyriticus*); Ditmars, 1905, p. 173 (*P. glutinosus*); Dunn, 1918, p. 459; Eckel and Paulmier, 1902, p. 400; Fowler and Dunn, 1917, p. 25; Hamilton, 1932, p. 83; Mearns, 1898, p. 323; Myers, 1930, p. 100; Noble, 1927, p. 3; Reed and Wright, 1909, p. 403; Wilmott, 1933, p. 164; Wright and Moesel, 1919, p. 64; 5th Ann. Rep't State Cab. Nat. Hist. 1852, p. 2; 25th Ann. Rep't N. Y. State Mus. 1873, p. 15; Fowler, 1940, p. 133.

General. Noble, 1931, p. 84 (*P. glutinosus*); Platt, 1931, p. 29; Shelford, 1913, p. 106; Smith, 1882, p. 726; Stejneger and Barbour, 1933, p. 11.

PLETHODON WEHRLEI (Fowler and Dunn)

(Proc. Acad. Nat. Sci. Phila., 1917, 69:23–24, pl. 4)

Wehrle's Salamander

Figures 2*j*, 4*i*, 39*d*, 45–46

At the present time, this species must be regarded as comparatively rare and very little is known of its life history and habits.

Description

Size. Females of this species may attain a length of six inches. The males I have measured have been much smaller but whether or not there is a definite sexual difference remains to be determined when more material is available.

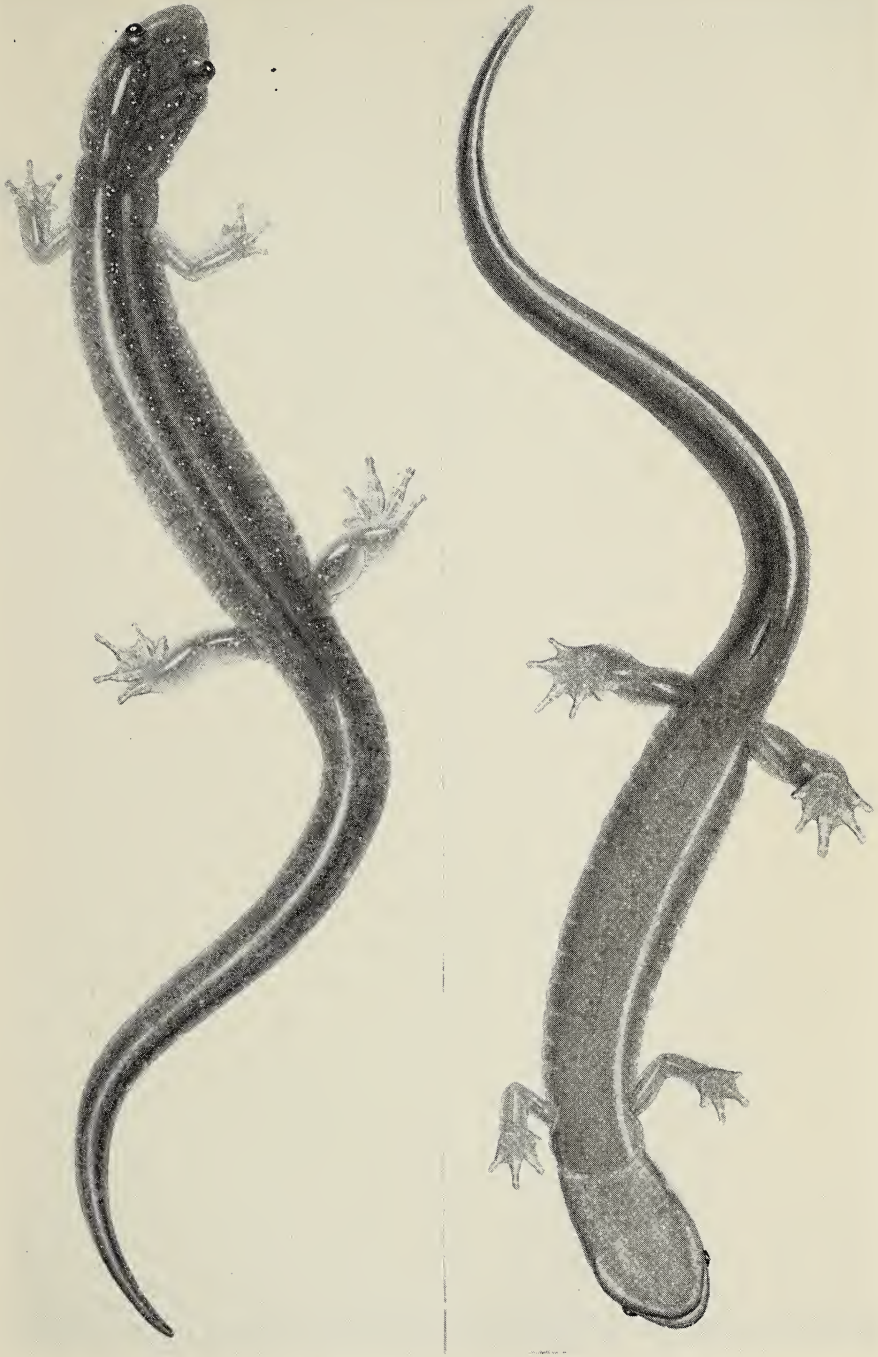


Fig. 45 *Plethodon wehrlei*. Adult female, actual length 125 mm. Allegany State Park, N. Y., June 9, 1933. H. P. C., del.

Measurements in mm given by Dunn (1926, p. 135) are as follows:

	TOTAL	HEAD	TRUNK	TAIL	LOCALITY
♀	152	14	58	80	Parkersburg, W. Va.
♀	127	14	51	62	Parkersburg, W. Va.
♀	125	13	52	60	Bristol, W. Va.
♀	113	14	56	43	Bristol, W. Va.
♀	67	13	46	8	Parkersburg, W. Va.
♀	53	9	30	14	Parkersburg, W. Va.
♂	126	12.5	50	63.5	Bristol, W. Va.

Measurements in mm of specimens from Pennsylvania and New York localities are given below:

	TOTAL	SNOUT TO VENT	TAIL	LOCALITY
♀	127	61	66	Port Allegany, Pa.
♀	115	59	56	Port Allegany, Pa.
♀	110	55	55	Port Allegany, Pa.
♀	107	65	42	Port Allegany, Pa.
♀	....	47	tip lost	Port Allegany, Pa.
♀	81	41	40	Port Allegany, Pa.
♂	118	62	56	Port Allegany, Pa.
♂	100	51	49	Port Allegany, Pa.
♂	76	49	27	Port Allegany, Pa.
♀	123	64	59	Allegany State Park, N. Y.
♀	113	57	56	Allegany State Park, N. Y.
Juv.	37	..	..	Allegany State Park, N. Y.

Hassler (1932, p. 96) without designating the sex, gave the measurements of two specimens taken near Olean, N. Y.:

TOTAL	SNOUT TO VENT	TAIL
135	67	68
103	57	46

The smallest specimen measured by Dunn had a length of 44 mm. The smallest specimen from Allegany State Park, N. Y., measured 37 mm in total length and was colored, in general, like the adults.

Form. This is a slender species with a long round tail which, in the females at least, may exceed the length of the head and trunk. The head is broadly oval in outline, widest immediately back of the eyes and tapering to the bluntly rounded and depressed snout. The eye is prominent with the pupil black and iris deep brown, its horizontal diameter about equal to the distance between the anterior angle and the nostril; the lower eyelid is provided behind with a vertical groove into which the upper lid fits. The gular fold is well developed and extends on the side of the neck. Back of the eye a narrow arched groove extends to the gular fold and is joined a short distance behind the angle of the jaw by a short, vertical groove. Viewed from the side, the commissure of the jaws is gently arched.

There are 16 or 17 costal grooves. If one each is counted in the axilla and groin, the number is usually 16. In some individuals, a groove above the insertion of the fore leg curves backward and joins another in the axilla, making a total of 17. There may be as many as 3 costal folds between the appressed toes but usually the distance is less.

The legs are well developed. Toes of the fore feet 1-4-2-3 in order of length, short, blunt and webbed at base. Toes of the hind feet 1-5-2-4-3 in order of length, the inner webbed almost to tip, the others at base. The tail is nearly round in cross section at the base and only slightly compressed, in some individuals, distally.

The surface of the skin appears smooth and shining but it is everywhere shallowly pitted. There are no conspicuous pores on the head but on the dorsal surface of the tail the glands are slightly enlarged and secrete an abundance of slime.

In the male, the vomerine teeth number six to eight in each series. The line of the teeth begins just outside the inner nares and curves inward and backward. In some, the vomerine teeth are continuous with the parasphenoid but in the majority there is a definite break between the two. In one male, the teeth were continuous on one side and separated on the other. The parasphenoid teeth are in two separate club-shaped patches beginning opposite the middle of the eye. In the female the vomerine teeth commonly number from seven to nine in each series and are separated from the parasphenoid.

The tongue is broad and flat and nearly fills the floor of the mouth. It is attached medially in front with the sides and posterior margins free.

Color. The color in life varies somewhat among different individuals. In some the ground color above is deep brown, almost black, except on the head where the brown may be a little lighter. The lower sides may be bluish brown flecked with irregular whitish spots and dashes. The legs are usually brown like the head and with fine light fleckings. The under surface of the head is conspicuously lighter than the venter and usually mottled with white. The belly and lower surface of the tail are uniformly light gray, the lower surface of the limbs with traces of flesh color.

In other individuals the general ground color has bluish reflections and the white fleckings are carried well onto the back and sides of the head below the eyes.

Sexual differences. Sexual differences are not well marked externally. There are papillae in the vent of the male and there

may be differences in proportions but not enough material is available to determine this point. Among the specimens in the collections of the Philadelphia Academy of Natural Sciences, one male was found in which there is a well-developed mental gland.

Activities of the Breeding Season

Nothing is known of the mating habits, spermatophores or the eggs of this species.

Habits

General. This is a secretive species, nocturnal in its habits. When exposed to the light and disturbed it exhibits considerable activity and seeks to escape by running and burrowing beneath surface materials on the ground. In this there is nothing to distinguish it from several other plethodontids.

Food. I have examined the stomach contents of a number of individuals and listed the following items: ants, lepidopterous larvae, cricket, beetles, cranefly adults, fragments of hymenopterous insects, aphids, mites, many fragments of undetermined insects, much vegetable debris and some sand.

Habitat

In New York and Pennsylvania localities I have collected the species on wooded hillsides. Near Port Allegany, Pa., where many specimens have been taken, they were found under logs and flakes of rocks on hillsides and in old quarries. In Allegany State Park, N. Y., the specimens first found were taken from beneath flat rocks and rotting logs in old second growth mixed deciduous and evergreen woods.

In my own experience, the majority of specimens have been found beneath stones or flat rocks rather than beneath logs. Hassler (1932, p. 95) also writes of collecting specimens from, "under stones at the edge of some woods, on a damp hillside. . . ."

The species in New York, at least, is more commonly associated with *Plethodon cinereus* than with its nearer relative, *P. glutinosus*. The latter seems to require more moisture in its environment or at least to have access to crevices and burrows that lead to damp situations. I have found *P. wehrlei* in situations that were nearly dry.

Netting (1932, p. 6), writing of the species in West Virginia, remarks: "I have found the species in cave entrances, in deep rock crevices, and near ice caves."

Remarks

As Dunn (1926, p. 135) has pointed out, *P. wehrlei* belongs to the group which includes *P. glutinosus, P. yonahlossee* and *P. metcalfi.* In appearance it perhaps most closely resembles *P. yonahlossee.* In New York, the only species with which it is likely to be confused is *P. glutinosus* from which it may be distinguished by its smaller size, more slender body, longer tail and unusually lighter throat. In ground color *P. glutinosus* is always much blacker and the white spots are larger, brighter and more abundant, and often present on the back.

Dunn (1926, p. 135) mentions the presence of red pigment on the dorsal surface but in none of the specimens I have examined has there been the slightest evidence of this color.

This species was added to the fauna of New York in 1927 (Bishop, 1927, p. 117).

Range

Western New York, Pennsylvania, West Virginia and Ohio.

Distribution in New York

General. Known only from Allegany State Park and near Olean.

Fig. 46 New York localities for *Plethodon wehrlei.*

Specific records. CATTARAUGUS: *Allegany State Park,* Hillside opposite Natural History School, July 1927, 5 ads., (Bishop, 1927, p. 117); Aug. 15, 1927, 1 ad., 1 juv. (Flossie Martin); July, 1931, 6 ads. and juv. (H. Jack); June 9, 1933, 2 ads. ♀; Oct. 19, 1934, 1 ad. U. R. No. 3438; Aug. 24, 1937, 4 ads.; May 7, 1938, 1 ad.; Oct. 15, 1938, 1 juv.; Mount Seneca, May 19, 1935, 1 ad.; 3⅓ mi. N.E. of *Olean,* May 13, 1931, 3 spec. A. M. N. H. No. A38058–59 (Hassler, 1932, p. 95).

Condensed Bibliography

Life history and habits. Bishop, 1927, p. 117 (*Plethodon wehrlei*); Netting, 1933, p. 6.

Distribution in New York. Bishop, 1927, p. 117; Hassler, 1932, p. 95.

General. Fowler and Dunn, 1917, p. 23; Dunn, 1926, p. 133; Walker, 1933, p. 224.

GYRINOPHILUS PORPHYRITICUS PORPHYRITICUS (Green)

(*Salamandra porphyritica* Green. Contr. Maclur. Lyc. 1827, 1:3, pl. 1, fig. 2)

Purple Salamander; Salmon-colored Salamander

Figures 3*c*, 4 *k–l*, 47–49, 52 *f–g*

The purple salamander has been regarded as one of the rarer species but, in localities where conditions are favorable for its development, it is often very abundant and sometimes outnumbers even the dusky salamander. It is graceful in body proportions, delicate in color and exceedingly active when aroused.

Description

Size. A series of 10 transformed individuals from Stamford, N. Y., varied from 127 mm to 193 mm with the average of 165 mm (6½ inches). Individual females may be almost as long as the largest males, but when a number of specimens of both sexes are measured, the males will be found to be somewhat longer. A series of 15 males selected at random from various New York localities ranged in length from 140 to 193 mm and averaged 166.06 mm. In a similar series of females the extremes were 120 and 180 mm, the average 149.4 mm. The average length of 34 specimens of both sexes was 160.2 mm (6⅜ inches).

The smallest transformed individual I have found measured exactly 100 mm in length. Dunn (1926, p. 262) records a specimen, undoubtedly abnormal, from Endless Caverns, Va., which was only 65 mm long and differed otherwise from the normal in its pattern of dark dots on a light red ground. The largest specimen I have found is a giant male 219 mm (8⅝ in.) long. In this the proportions are as follows: head length, 30 mm; width, 18.5 mm; tail from

posterior end of vent, 92 mm; distance between hind and fore legs, 72 mm; between appressed toes, 41 mm, or 8 costal interspaces.

Form. The body, while comparatively long and slender, is strong and well proportioned; the legs, particularly the hind pair, are stoutly developed. The toes of the hind feet are of moderate size, in order of length, 1-5-2-3-4. The toes of the front feet are rather short, 1-4-2-3, in order of length. The costal grooves are usually 17 in number, but occasionally individuals will be found with 18. There are about seven intercostal spaces between the appressed toes. The sides of the tail, on the basal half at least, are marked with vertical grooves which in many specimens are as conspicuous as the costal grooves. The tail is nearly oval in cross section at the base but gradually flattens towards the tip where the distal third is thin and often with a knifelike edge above. The gular fold is prominently developed and extends on the sides of the neck where it meets an undulating fold running to the eye. The eye is limited behind by a short, vertical crescentic groove. Gland openings are sometimes developed in an irregular row on the snout, between the eye and nostril, but elsewhere are inconspicuous except when discharging mucus. They are most abundant on the dorsal surface of the tail and may cover the skin with slime when stimulated.

The vomerine teeth are in a transverse, slightly arched series. They are usually developed in a single row, beginning behind and well outside the nares, arching gently forward, then backward to join the parasphenoids with which they are continuous. The parasphenoid teeth are arranged in several rows to form elongate, divergent club-shaped patches. The tongue is boletoid.

Color. As in the case of the red salamander, the purple salamander, following transformation, differs markedly from the more mature individuals. The ground color approaches salmon red and the darker reticulations or mottlings are less distinctly developed. This postlarval condition is probably of comparatively short duration, a kind of transition period between the strictly aquatic larval life and the sexually mature adult.

With age the ground color darkens and the mottlings or reticulations become for a time more distinct. In very old specimens the entire back may become very dark and pigment appears in flecks and small spots on the throat and belly, and in a dark band on the lower lip. Compared with the plates in Ridgway's Color Standards and Color Nomenclature (1912, pl. XL) the ground color of a normal, sexually mature adult is nearest army brown or between

Fig. 47 *Gyrinophilus p. porphyriticus.* a. Recently hatched larva, actual length 28 mm, Voorheesville, N. Y., Apr. 27, 1923. b. Fully grown larva, actual length 102 mm, Stamford, N. Y., June 25, 1922. c. Adult female, actual length 160 mm, Thacher Park, Albany Co., N. Y., June 15, 1922. d. Recently transformed, actual length 118 mm, Stamford, N. Y., June 25, 1922. E. K. O'B., del.

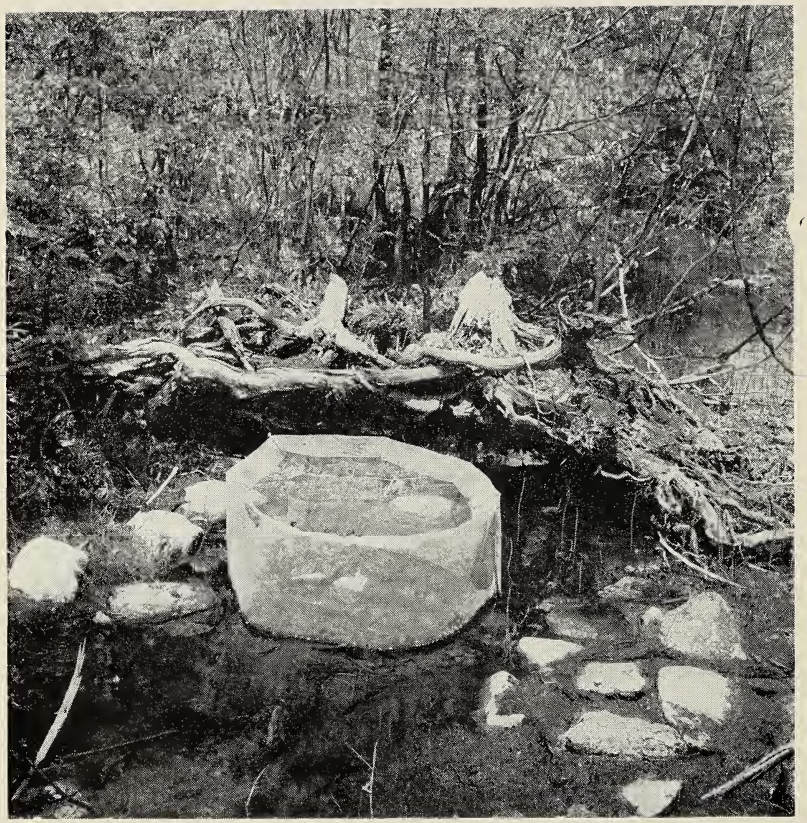


Fig. 48 Upper. Larva of *Gyrinophilus porphyriticus porphyriticus*, photographed in the shallow water of a spring at Voorheesville, N. Y., May 18, 1923. Lower. Spring near Voorheesville, N. Y., habitat of *Gyrinophilus*. The wire cage is buried in the muck of the bottom and the edges, turned in at the top, prevent the salamanders from crawling out.

that shade and wood brown. But the color varies somewhat in specimens of like age and the skin has a translucent character that gives an effect hard to describe. The lower sides are lighter than the back and sometimes the dark reticulations here inclose small light areas which appear to be arranged in fairly regular longitudinal lines. In dark individuals this arrangement is scarcely, if at all, evident. The belly is flesh-colored in life, except where the liver, showing through the transparent skin, imparts a bluish cast. The tips of the toes and the knee and elbow joints are sometimes conspicuously darker than the rest of the legs. From the eye to the nostril is a narrow light line bordered on the outer side by gray.

Sexual differences. Sexual differences are not strongly marked externally but the males average somewhat longer than the females. When the females are carrying well-developed eggs, they are visible through the skin of the belly. The peritoneum covering the testes of the male is black.

Activities of the Breeding Season

Mating. Nothing has been published concerning the mating habits of the purple salamander. The following account, therefore, of the activities of a pair of adults may be of interest. At noonday, on October 8, 1924, I witnessed, with a companion, Walter J. Schoonmaker, the peculiar performances of two specimens which were lying quietly at the bottom of an open spring in a swamp near Voorheesville, N. Y. The female could be recognized by the distended ovaries visible through the skin of the belly. The other individual which lacked these distinctive yellowish white patches, was regarded as the male.

When first observed, the two salamanders were lying motionless on their backs, each grasping the other with the jaws. A moment later they righted themselves and engaged in a kind of strenuous wrestling which involved turning and twisting the bodies and grasping with the mouth on the part of each, and apparently an effort by the male to present his cloaca to the snout of the female. The male held the female by the side of the head, shifting his grip from time to time but never entirely relaxing his hold for the period of a quarter of an hour during which the observations were made. The female, in turn, grasped the side of the male a short distance in front of the right hind leg and kept her hold throughout the struggle. Unfortunately our attention was diverted for a few seconds, and in that interval the salamanders separated and escaped. No sperma-

tophores were seen, although searched for carefully. The figure here given (figure 52 g, p. 267) was drawn from a sketch made in the field. In the light of the known habits of other species, perhaps this performance may be regarded as a normal activity, an effort on the part of the male to excite the female preliminary to fertilization.

Further evidence that the mating season begins in autumn, whether or not it may continue through the winter and spring, was revealed by dissections of males and females in which ripe spermatozoa were found in October. Males dissected in summer from June until approximately September 15th were found to have no sperm in the vasa deferentia (Dieckmann, 1927, p. 264). Finally, a male taken October 28, 1933, at Allegany State Park, N. Y., and preserved, was found to be holding in its vent a well-formed spermatophore in which mature sperm were present in numbers.

The presence of sperm in the spermathecae of the females, however, does not depend on season for they were found to be abundant in June, August and November specimens, moderate or scanty in July, scanty or absent in September, and absent in some animals in every month in which specimens were captured (Dieckmann, 1927, p. 264).

Spermatophores. The complete spermatophore of the purple salamander has not been described. That recovered from the vent of a male consisted of a gelatinous base and a whitish terminal part in which the spermatozoa were abundant. The salamander had been killed and hardened in formalin before the spermatophore was discovered. When found, only the clear gelatinous base was exposed externally and when this was removed the milky white terminal part remained attached in the usual position.

The egg-laying season. In females taken in the fall and winter and in early spring, the ovarian eggs of the majority of specimens show through the skin as elongate, yellowish white patches, the masses occupying the ventro-lateral region and extending from the fourth or fifth costal groove to the hind legs. Before the eggs were discovered in the field, I had dissected specimens at various times of the year and observed that, in general, there was a gradual increase in size of ovarian eggs from those very small in females taken in May to those apparently mature in specimens collected in October, November and again in April. In view of the evidence afforded by these dissections, I had concluded that in all probability the eggs were deposited in the spring. Additional dissections, however, soon made it apparent that the problem was not to be so easily solved. Females with apparently mature eggs were found in, or reported found in, May and June and eggs in the field August 8th.

These discoveries extended the egg-laying season to include the summer months.

The table given below gives the results of my own dissections of specimens from various localities and some additional data secured from other sources.

LOCALITY	DATE	SIZE OF OVA MM	RIGHT OVARY	LEFT OVARY	TOTAL NO.	SIZE OF ♀ MM	REMARKS
Port Allegany, Pa....	Apr. 5, 1921	3.00	22	22	44	...	.....
Erie Co., N. Y.....	Apr. 6, 1921	3.00	..	..	..	...	R. R. Humphrey, coll.
Thacher Park, N. Y..	May 8, 1928	0.33	..	..	..	...	.....
Ithaca, N. Y.....	May 12, 1906	mature	..	..	..	...	Reed and Wright
Enfield Glen, N. Y...	May 18, 1911	very small	..	..	..	...	1909, p. 403
McLean, N. Y.....	May 27, 1919	0.33	..	..	..	155	.....
Thacher Park, N. Y..	May 27, 1923	0.50	..	..	..	180	.....
Thacher Park, N. Y..	May 30, 1923	0.50	..	..	..	150	.....
Thacher Park, N. Y..	May 31, 1916	0.33	..	..	..	...	.....
Friendship, N. Y.....	June 5, 1933	3.5	..	..	..	191, 155, 163	..... Three specimens
Friendship, N. Y.....	June 5, 1933	0.33	..	..	..	156	.....
Onondaga Valley, N.Y.	June 5, 1916	very small	..	..	..	...	.....
Thacher Park, N. Y..	June 15, 1922	0.5	..	..	..	165	Tip of tail lost
Thacher Park, N. Y..	July 11, 1923	1.0	..	..	..	...	.....
Allegany St. Pk, N. Y.	Aug. 13, 1926	2.0	20	35	55	156	.....
Allegany St. Pk, N. Y.	Aug. 13, 1926	2.0	..	..	..	165	.....
Erie Co., N. Y.....	Aug. 15, 1925	3.0	..	..	..	...	R. R. Humphrey, coll.
Richford, N. Y.....	Oct. 11, 1924	3.0	70	62	132	...	C. U. collection
Stamford, N. Y.....	Oct. 12, 1922	2.5	53	48	101	168	.....
Stamford, N. Y.....	Oct. 13, 1922	2.0	61	54	115	172	.....
Allegany St. Pk, N. Y.	Oct. 28, 1933	1.0	..	..	..	155	U. R. collection
Voorheesville, N. Y..	Nov. 4, 1922	3.0	21	33	54	150	.....
Wilton N. Y.....	Nov. 5, 1923	2.5–3	27	31	58	173	.....
Erie Co., N. Y.....	Nov. 19, 1923	2.5	..	..	..	...	R. R. Humphrey, coll

These dissections show that females of large size but with small ovarian eggs have been taken in May, June and July and that the egg complements of the year had already been deposited. Females with large eggs have been taken in April, May and June and again in August, October and November. The eggs reported by Green were found August 8th and were probably laid in July. Thus, apparently mature eggs have been found throughout the spring, summer and fall months, indicating an extended egg-laying season. However, since the majority of specimens having small ovarian eggs have been taken in May and June, it is probable that this is the season of greatest activity.

The data presented above may be supplemented by records of dissections made by Dieckmann (1927, p. 264).

DATE	PRESENCE OF SPERM IN SPERMATHECAE	SIZE OF LARGEST OVA IN MM AND DEPOSITION OF YOLK	LENGTH OF ANIMAL IN MM	
Mar.....	.....	0.41; yolk absent.....	167	
Apr. 6th.....	Absent (Spring captivity)...	2.50; yolk abundant....	165	
May 2d.....	Absent.....	1.00; yolk scanty.....	153	
May 3d.....	Absent.....	minute.....	150	plus
June 19th.....	Absent.....	0.68; yolk scanty.....	143	plus
June 26th.....	Abundant.....	2.75; yolk abundant....	170	plus
July 1st.....	Moderate.....	0.97; yolk moderate....	165	2 specimens
July 14th.....	Scanty.....	.....	155	
July 24th.....	.....	0.32; yolk absent.....	...	
July 25th.....	Absent.....	.....	145	
Aug. 15th.....	Abundant.....	2.70; yolk abundant....	135	
Aug. 15th.....	Absent.....	1.00; yolk scanty.....	133	
Sept. 25th.....	Scanty.....	1.70; yolk abundant....	165	
Sept. 26th.....	Absent.....	minute.....	120	
Nov. 19th.....	Abundant.....	2.25; yolk abundant....	175	
Nov. 19th.....	Absent.....	minute.....	155	

The 120 mm specimen taken September 26th and the 133 mm August 15th specimen are doubtless immature and may be disregarded. Leaving these specimens out of consideration it is again evident that females with small ova have been taken in May, June and July and in addition in March and November. Females with large ova were taken in April, June, August and November, a period covering eight months and corresponding exactly with that obtained by my own dissections. These data would seem to justify the following conclusions: (1) Females carrying small ovarian eggs late in the fall may be maturing them for the first time. In this connection it is perhaps significant that these specimens are smaller than the average and lack sperm in the spermathecae. (2) In females taken late in the season and carrying large ovarian eggs, sperm were abundant, indicating again, a fall mating period.

Taken altogether, observations on living animals and records of dissections indicate the following: (1) There is an autumnal mating season, the mature sperm being absent in the vasa deferentia of males from approximately June 1st to September 15th. (2) Females generally deposit their eggs during the spring and summer months from May through July. (3) In some instances, females may deposit their eggs in autumn since eggs of large size are found at this season, the spermathecae of some females are filled with sperm and one female taken in March had already deposited her season's complement. (4) Females that have mated in the fall may carry the sperm through the winter in the spermathecae. (5) The sperm found in females between June and September must have been acquired in a fall or early spring mating.

The egg-laying process. The deposition of eggs in the field has not been observed. Females stimulated by pituitary transplants, however, (Noble, 1932, p. 12) or by injections of an aqueous alkaline extract of whole sheep's pituitary often respond by depositing eggs in aquaria. Observations on the activities of stimulated specimens in captivity are of value, but should not be accepted as representing normal behavior until carefully checked with specimens observed under natural conditions. The following account of the egg laying is based on observations of injected specimens. Four females taken May 28th near Friendship, N. Y., were each given daily injections of ¼ cc alkaline solution of whole sheep's pituitary beginning June 1, 1933. Specimen No. 1 responded by depositing a few eggs on the afternoon of June 5th, many on June 6th when injections stopped, and continued laying until June 8th when a total

of 83 had been deposited. Specimen No. 2 responded on June 5th by depositing 60 eggs and none thereafter although given injections a day or so longer. Specimen No. 3 deposited a few eggs on June 5th and none thereafter although again stimulated. No. 4 failed to respond and on dissection was found to have eggs only .33 mm in diameter. A male stimulated during the same period failed to deposit spermatophores, which is not surprising in view of the fact that the normal mating season is probably in the fall.

While depositing eggs, the female turned herself upside down, beneath a flat stone supported an inch or so above the bottom of the aquarium, and applied her vent to the lower surface. The trunk was strongly arched and supported by the tips of the toes of the fore legs and the flatly placed hind feet. The tail was also arched, the tip only in contact with the stone. As each egg was extruded, the tail was slightly undulated, the vent more closely applied to the stone and pressure exerted to insure attachment. The eggs were usually placed close together, the female shifting her position slightly after depositing an egg.

The egg mass. The discovery of the eggs of the purple salamander under natural conditions has been reported but once. The account is given by Green (1925, p. 32) as follows:

Mr. R. W. Wehrle sent me fifteen eggs and one specimen of an adult *Gyrinophilus porphyriticus* which he had found August 8, 1924, about two miles from Indiana, Pennsylvania. They were found in an old spring which was filled up with stones and brush and were clustered to the bottom of a fair-sized stone over and around which water was flowing. A number of other purple salamanders were found in this spring near the stone; no other species were found. Each egg is enclosed in an individual jelly-like transparent mass which maintains its spherical shape when in water. They are about nine mm in diameter and were fastened together and to the stone so tight that they were removed with difficulty. The color is a tawny olive which probably is largely due to the mud of the bottom. The dissection of three of these eggs showed that the head folds of the embryo were just starting to develop and would indicate that they were but a few days old.

The account given above agrees in essential details with the observations on the eggs deposited by stimulated females and also with the conditions observed in the case of the related species, *Gyrinophilus danielsi* (Bishop, 1924, p. 89).

Judging by dissections of mature females, the number of eggs deposited varies in number from 44 to 132. A single stimulated specimen deposited 83 in the three-day period June 5 to 8, 1933.

A second individual deposited 60. Noble and Richards (1932, p. 13) reported the case of a stimulated female that deposited 93 eggs.

Development

The egg and its envelops. When first deposited the individual egg with its envelops is almost spherical and is broadly attached by the outermost envelop. After 24 hours, the two envelops next within become somewhat pear shaped, the smaller part opposite the point of attachment. The fresh eggs from stimulated females have a diameter of about 3.5 mm and with the envelops a total diameter of 9 mm.

The vitelline sphere itself is light yellow and without pigment. The closely adherent vitelline membrane is not apparent. Next without, is a thin envelop inclosing a thin, slightly milky fluid; the next definite layer is clear and a little thicker; the third layer has about the thickness of the first and is also slightly milky. The outermost layer has a diameter exceeding that of the other three combined. It is limited externally by a very thin elastic membrane and incloses a jellylike substance which is thin and viscid (fig. 4, k-l).

Noble and Richards (1932, p. 11) have described and figured the eggs of *Gyrinophilus* obtained by stimulating females, but their drawing is made from an egg fixed in formalin and is somewhat distorted.

The incubation period. Nothing is known of the length of the period of incubation.

The newly hatched larva. The smallest larvae of *Gyrinophilus* I have collected measured 26, 27 and 28 mm long respectively. The smallest was taken July 29, 1927, at Thacher Park, N. Y., in the bed of a small spring, the 27 mm specimen was found April 5, 1924, beneath a stone in a small spring-run near Voorheesville, N. Y. On April 28, 1923, in the same swamp at Voorheesville, a 28 mm specimen was found beneath a log in water.

Pope (1915, p. 15) records specimens from Manchester, Maine, only one inch long, taken April 19, 1915, and apparently recently hatched. Reed and Wright (1909, p. 403) mention, without definite measurements, small larvae taken June 29, 1901, from a cold brook near Ithaca, N. Y. All these records point to an early spring and summer hatching period over at least part of the range of the species. As I have shown elsewhere (Bishop, 1924, p. 91), the eggs of the closely related *Gyrinophilus danielsi* hatch late in October and the larvae have an average length of about 25 mm. It is thus reasonable

to suppose that larvae of *G. porphyriticus* of about the same size were recently hatched.

The areas free from pigment in the young larva are dull yellowish white. Thus the entire ventral surface, except for small spots on the sides of the throat and the ventral tail fin, are of this uniform color. The dorsal surface is well pigmented, light brown with a tinge of lavender, and the color extends low enough on the sides to involve the lower lip, the upper half of the limbs and the sides of the tail. The pattern is well developed. Along the midline of the back a narrow pigmented band extends from the back of the head to the base of the dorsal tail fin. On either side of the band, and on the head, the pigment is arranged either to form a reticulated pattern over the dull yellow ground color, or the light areas are developed as small rounded spots scattered irregularly over the surface. There is only a slight indication of the light line that runs from the eye to the nostril in older specimens. In fact, in the recently hatched purple salamander, this light line is less well developed than in red salamander larvae of the same size. The tail is mottled, particularly on the dorsal keel, and the gills, too, are lightly tinted. The lower sides are perhaps more uniformly pigmented than the back and upper sides, and the color ends abruptly along a straight line between the legs.

The proportions of the head, trunk and tail are significant when distinguishing the purple larva from the larva of the red salamander. In the former, the head comprises about one-fifth of the total length and the tail three-sevenths. In the larval red the head is one-sixth the total length, the tail five-twelfths.

The differences between the young larvae of these two species may be summarized briefly as follows: The larval purple is longer and slimmer; the head is longer. The middorsal stripe is constant in the purple larva and entirely lacking in the larval red. The dorsal pattern is often reticulated or mottled in the purple and finely specked in the red.

Length of larval period. Young larvae, apparently recently hatched, have been taken in April and July. These vary in length from 26 to 28 mm. Other larvae taken during April, May and June vary in length from 57 to 135 mm and may be resolved into groups that appear to represent the annual growth to transformation. An average length of 63.6 mm is attained during the first year, basing the figure on measurements of specimens taken at the same locality at essentially the same time of year and assuming that they

may have hatched at approximately the same time. These vary from 57 to 65 mm. Another group which may represent the growth of two years, have an average length of 89.9 and extremes of 82 and 97 mm. The third lot varies from 108 to 135 mm and averages 123.9 mm.

The figures just presented may approximate the actual annual growth of the larvae or, due to differences in hatching time, they may be wide of the mark. Some support for the estimates, however, is to be found in the measurements of a series of five larvae taken in a spring at Thacher Park, N. Y., July 29, 1927. These measured respectively, 26, 51, 88, 102 and 127 mm, the two larger specimens probably of the same age.

The measurements of another series of larvae taken during August 1926 in Allegany State Park give additional data on which to base estimates of growth. These vary in length from 42 to 115 mm and appear to fall into groups as follows: The 42 mm specimen probably represents the young of the year and if hatched in April, is approximately four months old. In the next series, the larvae range from 68 to 81 mm and average 72.8; the third group has an average length of 99.6 mm and extremes of 90 and 115 mm. During this period, some recently transformed specimens having an average length of 106.5 mm were also taken.

The measurements of the specimens comprising the three groups discussed above, may be arranged in tabular form as follows:

DATE		1 YEAR	2 YEAR	3 YEAR
April–June.....	26–28	63.6	89.9	123.9
July 29, 1927.....	26	51.0	88.0	114.5
August, 1926.....	42	72.8	99.6	106.5 (just transformed)

The mature larvae. The larvae of this species sometimes attain a length of 135 mm before transforming, a specimen of this length having been taken April 13, 1926, at Voorheesville, N. Y. At this time the pattern and colors are practically those of the adult but lighter, clouded or reticulated markings on a light ground color. Some individuals are tinged with salmon-red.

Transformation. I have taken specimens in August with the gills reduced to mere stubs. One collected in Breed's run, Allegany State Park, August 18, 1926, measured 105 mm in length; another from the same locality, 108 mm. Other specimens apparently recently transformed have been taken in October and June at Stamford, N. Y., and measure respectively 127 mm and 120 mm in length. Reed and Wright (1909, p. 403) found a transforming

specimen 115 mm on March 14, 1903. Other records include the following: Allegany State Park, July 1931, Woodville, Ontario county, N. Y., September 1, 1932; Voorheesville, April 13, 1926.

The specimen figured is a young female, 120 mm long, taken June 25, 1922, at Stamford, N. Y. The colors and pattern are described somewhat in detail under the color description of the adult.

It is probable that larvae may transform at any season of the year.

Development to maturity. The smallest fully adult female I have taken measured 150 mm in total length. Since this species transforms at an average length of about 116 mm probably a year or so is required to attain maturity.

Males apparently mature at a smaller size. Three taken October 28, 1933, at Allegany State Park measured 131, 139 and 156 mm. The smallest individuals in which sperm or large ova were found by Dieckmann (1927, p. 264) measured 135 mm.

Habits

The adult purple salamander hides by day beneath stones, logs and old water-soaked boards or among the roots and stones imbedded in the banks and bottoms of streams and springs. Only under stress of the excitement attending the breeding activities, are they to be found abroad by day. The larvae, particularly the smaller ones, are more diurnal in their habits and may sometimes be seen moving about among the stones on the stream bottom. Larger larvae, like the adults, seek the protection of bottom rubbish, of stones and stranded logs. Occasionally a specimen is found on land a considerable distance from water and at night the adults are given to wandering about sometimes from one stream or spring to another.

Both larvae and adults are extremely active if disturbed and seek to escape by swimming and burrowing. When grasped roughly they wriggle violently and, aided by their secretion of slime, often make their escape. They may be collected without trouble if handled gently. When swimming freely in open water, the body is thrown into eel-like lateral undulations, the legs being held closely to the sides.

Specimens in captivity live for a considerable time if provided with running water and will often remain below the surface for long periods. Sometimes they rise to the surface and, supporting themselves with the front feet, lie for hours with the tip of the nose out of water. In this position I have also found them in the field when

a carefully lifted stone revealed a specimen in its hiding place. Extensive burrows are tunneled through the water-soaked soil, by the side of a spring or stream, with the exit beneath a stone or log. Dunn (1926, p. 264), quoting G. M. Allen, writes of a specimen, "dug up in repairing a road at about three feet below the surface."

Winter is a period of relative inactivity for this species, and many specimens are buried deeply beneath the bed of the stream or spring. They are active enough to eat, however, and an examination of the stomach contents of specimens taken in midwinter, reveal an abundance and variety of food scarcely less varied than that of summer.

Food. The purple salamander is carnivorous and cannibalistic. Specimens handled roughly, when captured, frequently disgorge their last meal which may have consisted of two-lined salamanders, dusky salamanders or a small frog. Pope and Noble (1921, p. 80) put on record the case of a purple salamander which, confined in a box with dusky salamanders, ate two and later disgorged them. Wright and Haber (1922, p. 31) present some notes on the carnivorous habits of the purple salamander and list among the food items the following species eaten while in confinement: four-toed, two-lined and dusky salamanders, and a young wood frog. Haber (1932, p. 32) writes of its food habits:

> The contents of the stomach reveal the fact that they are insectivorous in their habits, feeding on aquatic insects entirely. In captivity, stone-fly larvae, black-fly larvae, many species of Ephemeridae were relished and taken rather greedily. Young crayfish were given, the hard chitinous exo-skeleton was cast aside, but the soft parts were taken readily. On one occasion the abdominal cavity of an adult appeared to be greatly distended. At the same time it was observed that two larvae had disappeared from the cage. The following day the same adult was completely incased with a prolific growth of Saprolegnia, which undoubtedly caused its death. Upon careful examination of the alimentary tract of the individual, it was discovered that it had devoured two larvae of its own kind, one about 110 mm and the other 72 mm long. According to this particular instance, the species may be said to be cannibalistic in its habits. The larvae feed on smaller aquatic insects and crustacea.

Surface (1913, p. 98) examined 26 stomachs containing food and reported earthworms, snails, undetermined crustacea, spiders, fly larvae, ground beetles and myriapods as composing the diet.

Smallwood (1928, p. 94) reporting on *Gyrinophilus,* listed only traces of insects and grass.

Hamilton (1932, p. 85) employing the percentage-by-bulk method in determining relative amounts of the various food items, lists the

following obtained from 26 specimens: beetles, 14.2; stoneflies, 13.4; salamanders, 10; cast skins, 9.4; midge larvae, 8; hymenopterous remains, 7.8; centipedes, 6.5; mayfly nymphs, 5.2; caddis-fly larvae, 5; snails, 4; annelids, 2; spiders, 1, and extraneous matter, 13.5 per cent. Much of the food was secured under water in swift spring runs. The salamanders eaten were *Desmognathus*.

During the summer and fall of 1932 Dr Norman W. Davis collected and examined 80 specimens from the vicinity of Ithaca, N. Y., and has kindly permitted me to present a summary of his findings.

The following list gives the percentage of stomachs in which the different types of food were found.

Invertebrate

Ephemeridia	26 %	Gastropoda	5%
Trichoptera	24 %	Hymenoptera	5%
Coleoptera	21 %	Hemiptera	3%
Diptera	20 %	Chilopoda	3%
Annelida	15 %	Crustacea	2%
Araneida	8.7%	Plecoptera	1%
Diplopoda	6 %	Hydracarina	1%

Vertebrate

Caudata.....2.5%

It is obvious that insects are more frequently taken than any other single item, 49 of the 80 specimens examined having remains of one or more in the intestinal tract. Spiders were taken by seven specimens, earthworms by 12 and larval salamanders, *Desmognathus fuscus* and *Gyrinophilus,* by two.

Habitat

The larvae are entirely aquatic but the adults during the warmer months are usually to be found hiding beneath stones or logs in damp situations but not actually in the water. They frequent the margins of springs and streams and occupy natural or excavated cavities which usually communicate with the water and into which they slip, if possible, when disturbed. Some individuals, of course, are to be found in water at any season but it is likely they spend most of their time during daylight hours in the saturated soil a few inches above the water level.

During the colder months, the adults bury themselves beneath the stones or logs in the streams or springs and spend the winter below the surface. In summer when the streams are low they again bury themselves deeply and whether or not they are in the

water, they find situations that are constantly moist. In and along streams and springs where the purple salamander may have been exceedingly common during the spring and summer, they sometimes almost completely disappear with the first cold weather and remain in hiding until the weather again moderates. They are not entirely inactive, however, for specimens taken in midwinter and examined were found to have eaten a variety of food that must have occasioned considerable exertion.

In certain limestone regions where streams are bedded with flat rocks, they are particularly abundant and an hour's active collecting may result in the capture of a dozen or more. Near Albany, N. Y., they are to be found along the streams that break out of the base of the Helderberg escarpment. They are also found in springs and streams of cool ravines and swamps where old logs, stones or overhanging banks offer safe retreats. They are not confined to wooded areas for many occur in open springs and streams of barren hillside meadows. Nor is the species entirely confined to shallow waters. "Dr Thomas Barbour, near Tupper Lake, in the Adirondacks, caught a larvae in a minnow trap in a deep stream," and an adult male was found under a rock in several feet of water near the shore of Big Tupper lake (Dunn, 1926, p. 264). Larvae in the collection of the New York State Museum were taken in Chilson lake, N. Y., and Shawanese lake, Pa.

Occasionally specimens have been found in fairly dry situations. On August 4, 1924, a large specimen was found in a rotten log overhanging a small swamp stream near Van Etten, N. Y. At the same time and place, a second individual occupied a crevice in a log that lay near-by. W. P. Alexander found a large specimen in a rotten log on a fairly dry hillside in Allegany State Park, July 14, 1927. Norman W. Davis found a specimen under a large boulder six feet from the edge of a stream, more than a foot above the water level and in a situation where the soil was only slightly moist.

The most important elements in the habitat of the species are clear cold waters of springs, streams and lakes, and logs or stones under which to hide. They will not long survive in warm or muddy waters or in streams that have been polluted by commercial wastes.

Near the sources of spring-fed streams they seem to reach their greatest abundance and to such situations the collector may well turn when investigating territory with which he is not intimately acquainted.

In the northern parts of its range, the purple salamander is often found in streams associated with the red salamander, *Pseudotriton r.*

ruber, the dusky salamander, *Desmognathus f. fuscus,* and the two-lined salamander, *Eurycea b. bislineata.* In streams where both the red and purple salamanders occur, the adults are likely to be discovered beneath a stone or log near the water's edge. The larvae apparently select slightly different situations. It is not unusual to find the larvae of the red salamander foraging in beds of cress, *Chara* or other water weeds, while in the same stream and only a few feet away, the purple larvae would hide beneath the bottom rubbish or among the stones. The dusky salamander, somewhat less aquatic than the purple, is a competing species but spends much of its time in the saturated soil at the stream margin. Both this species and the little two-lined salamander feed on small aquatic organisms, insects etc., and in turn are preyed upon by the purple salamander.

Dunn (1918, p. 12) writes of this species, "Larvae of *Gyrinophilus* are found quite frequently, whereas the adult is rarely found." On the afternoon of October 12, 1922, I collected 12 specimens at Stamford, N. Y., ten of which were adults. Of 30 specimens taken during August 1926, at Allegany State Park, 15 were adults. Of 129 specimens collected in various localities, only 53 were larvae. Altogether I have collected some 300 specimens of the purple salamander and fully 50 per cent have been adults. Pope and Noble (1921, p. 79) write of the purple salamander as one of the rarest salamanders of Pennsylvania, but from my own experience in that state, I would regard it as abundant in many localities. Wright and Haber (1922, p. 31) also comment on the abundance of the species, both in New York and Pennsylvania, and cite the experience of Professor Ralph J. Gilmore, who, with little difficulty, collected a hundred or more adults from one locality.

Perhaps the most striking evidence of the abundance of this species in favorable situations is given by Hassler (1932*a,* p. 307, 308): "One hundred forty-four of these large salamanders were caught, tagged, and returned to one particular spring, and nearly fifty more were observed there, but not tagged."

Remarks

No general account of the purple salamander has appeared other than that of Dunn (1926, p. 259) who summarized about all that was known of the life history and habits. Smith (1882, p. 730) commented briefly on the habitat of the species and remarked that it attempted self-defense by snapping savagely. I have seen them open their mouths when grasped tightly but have never interpreted this action as snapping. Cope (1869, p. 109; 1889, p. 157) also

writes of the purple salamander that it attempts self-defense, perhaps suggesting this idea to Smith. Reed and Wright (1909, p. 403) present habitat notes and observations on transformation and young larvae.

Studies of the food of this species have been made by Surface (1913, p. 85), Hamilton (1932, p. 85), and Norman W. Davis (in mss). Additional notes on food and feeding habits have been presented by Pope and Noble (1921, p. 80), Wright and Haber (1922, p. 31) and Smallwood (1928, p. 94). Pope (1915, p. 14) recorded recently hatched larvae taken April 19, 1915, from a spring near Manchester, Maine. The eggs of this species found by R. W. Wehrle were first reported by Green (1925, p. 32). Noble and Richards (1932, p. 11) described in detail and figured the egg of *Gyrinophilus* obtained from females stimulated by pituitary transplants. Dieckmann (1927, p. 258) studied and reported on the cloaca and spermathecae of the species and presented data on breeding habits and egg-laying.

Range

"Maine to Ontario, Canada southward through the eastern states to Virginia, Ohio, Tennessee and northern Alabama." (Stejneger and Barbour, 1933, p. 15.)

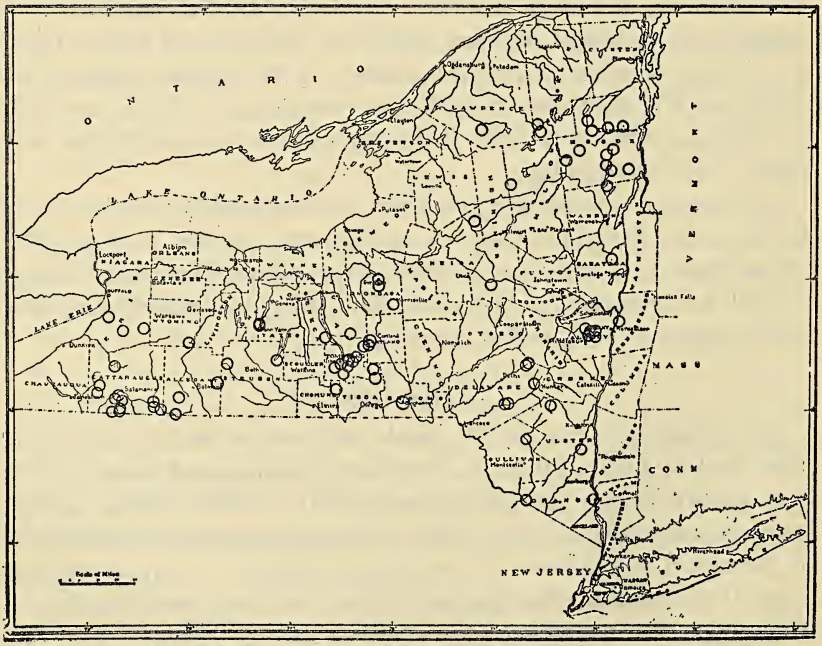


Fig. 49 New York localities for *Gyrinophilus porphyriticus porphyriticus.*

Distribution in New York

General. Throughout the State in suitable localities except Long Island and Staten Island; rare in sandy areas along southern shore of Lake Ontario.

Specific records. ALBANY: *Clarksville,* May 8, 1926, 1 small larva; *New Salem,* Apr. 13, 1927, 1 ad.; *Thacher Park,* June 15, 1922, 2 ads., N. Y. S. M. No. 9240–41; July 11, 1922, 1 female; July 19, 1922, 2 spec.; May 6, 1923, 1 ad. male; May 27, 1923, 1 ad. male, 2 ad. females, 1 larva; May 30, 1923, 1 female; June 1, 1923, 2 larvae; Mar. 29, 1924, 1 ad., N. Y. S. M. No. 1466 (S. C. B. and W. J. S.); June 11, 1924, 1 ad., 1 larva; Oct. 4, 1924, 4 ads.; May 2, 1925, 1 ad. male; June 28, 1927, several larvae; July 29, 1927, 2 ads., 5 larvae (T. I. Storer and S. C. B.); Aug. 31, 1927, 1 ad. under log beside stream (S. C. B. and D. Cook); May 8, 1928, 1 ad. female; July 7, 1928, 1 ad.; *Voorheesville,* June 15, 1922 (Bishop, 1923); July 12, 1922, 1 ad.; Dec. 3, 1922, 1 ad., 1 larva; June 19, 1923, 1 larva; Oct. 3, 1924, 1 larva; Sept. 25, 1925, 1 larva; Apr. 13, 1926, 1 larva, N. Y. S. M. No. 3040; July 29, 1927, 1 ad., 3 larvae (T. I. Storer and S. C. B.); *Voorheesville, Dolder's swamp,* July 7, 1922, 1 ad., 2 larvae; Oct. 28, 1922, 1 ad.; Nov. 4, 1922, 3 ad. males, 1 ad. female; Apr. 4, 1923, 1 ad.; Apr. 27, 1923, 1 larva; Apr. 5, 1924, 2 larvae, N. Y. S. M. No. 1544–45; Apr. 15, 1924, 1 ad. (S. C. B. and W. J. S.); May 5, 1924, 1 larva; Oct. 8, 1924, 1 male, 1 female (S. C. B. and W. J. S.); Mar. 26, 1925, 1 ad. female, 1 juv., 1 larva; June 11, 1925, several larvae; Apr. 13, 1926, 1 larva; Apr. 16, 1933, 1 ad. (S. C. B. and H. Chrisp). ALLEGANY: *Alfred,* May 1934, 1 larva (F. W. Ross); *Ceres, Bell's run,* Aug. 30, 1926, 1 larva; between *Friendship* and *Richburg,* May 28, 1933, 8 ads., U. R. No. 3008–11 (M. Hall). BROOME: *Binghamton,* abdt. in springs, 1939 (H. Trapido). CATTARAUGUS: *Allegany State Park,* Blacksnake Mt., 1 trans., 1 larva (Homer Jack); Breed's run, Aug. 18, 1926, 7 ads., 1 trans., 1 larva, N. Y. S. M. No. 3112–14, 3106–11; Oct. 22, 1932, 7 ads., 3 larvae, U. R. No. 3197; Oct. 28, 1933, 7 ads., and larvae, U. R. No. 3196; Mt. Tuscarora, Oct. 24, 1937, 1 juv.; Natural Hist. School, July 14, 1927, 1 ad. (W. P. A.); May 7, 1938, 3 ads.; Ranger trail, Oct. 29, 1933, 3 larvae (M. Hall); Oct. 18, 1935, 1 ad.; Oct. 23, 1937, 1 ad.; Oct. 15, 1938, ads. and larvae; Red House run, Aug. 25, 1926, 1 ad., N. Y. S. M. No. 3099; Red House valley, Balsam swamp, Aug. 13, 1926, 6 ads., 8 larvae, N. Y. S. M. No. 3124–3135, 3182–83; Slide hollow, June 22, 1924, 2 ads., N. Y. S. M. No. 1567 (S. C. B. and B. S. B.); Aug. 10, 1926, 6 larvae, N. Y. S. M. No. 3192–97 (S. C. B. and W. P. A.); Stony run, Aug. 19, 1926, 1 ad., several larvae; *East Randolph,* Feb. 19, 1931, 7 spec. (N. M. Fuller); *Otto,* Feb. 20, 1931, 3 spec. (N. M. Fuller); *Playfords spring,* Olean Township, Feb. 13–20, 1931, 8 spec. (N. M. Fuller); *Portville,* many ads., and larvae (Hassler, 1932); *Big Hatch spring,* Feb. 1931, 1 larva (N. M. Fuller); *Brook springs,* Feb. 1931, 1 ad. (N. M. Fuller); Chaffee springs, Feb. 1931, 2 spec. (N. M. Fuller); *Lowe farm,* Feb. 3–4, 12, 18, 1931, 13 ads. and larvae (N. M. Fuller); 2 mi. N. E. of *Waterboro,* Oct. 24, 1937, 1 ad. CAYUGA: *Locke,* Mar. 1922, 1 spec., C. U. (C. W. Leister). CHEMUNG: near *Van Etten,* Aug. 4, 1924, 1 ad., N. Y. S. M. No. 1583 (S. C. B. and W. J. S.); 1 ad., A. M. N. H. No. 22,543. CHENANGO: (Fowler and Dunn, 1917). CORTLAND: *Beaver brook,* May 2, 1934, 11 spec. U. R. No. 3413; *Chicago bogs,* 1887, C. U.; May 31, 1923, C. U.; Apr. 12, 1924, ads., C. U. (D. L. Gamble); May 27, 1927, larvae, C. U. (J. Moesel); Oct. 10, 1933, 1 ad., U. R. No. 3195 (W. J. Koster); *Gracie,* Beaver brook, May 2, 1934, 1 ad., male, 1 ad. female, 1 larva, 8 trans., U. R. No. 3413. DELAWARE: *Downsville,* July 1, 1935, 14 ads. and juv. U. R. No. 3867 (Zorsch and Bailey); *Halcottsville,* Brook. Mus. No. 933 (Dunn, 1926); *Stamford,* June 25, 1922, 5 ads., 8 larvae, N. Y. S. M. No. 9249–58, 9266 (S. C. B. and H. Chrisp); Oct. 12, 13, 1922, 10 ads., 2 larvae, N. Y. S. M. No. 9322–31 (S. C. B. and H. Chrisp); June 10, 1923, 1 ad., 2 larvae (S. C. B. and H. Chrisp); Oct. 11, 1924, 2 ads. (S. C. B. and

H. Chrisp); May 15, 1927, 2 ads., 10 larvae, N. Y. S. M. No. 3845–46, 3848–50, 3853–56 (W. J. S.); Jan. 24, 1928, 3 spec., N. Y. S. M. No. 3847, 3851–52 (W. J. S.); Aug. 1933, 1 spec., U. R. No. 3280 (H. Chrisp); July 4, 1935, 1 larva. ERIE: *Boston,* Apr. to Oct. 1925, several (R. R. H.); *Hamburg,* June 1, 1905, C. U. (A. A. A.); *Holland,* Apr. to Oct. 1925, several; Aug. 15, 1925, 1 ad. female (R. R. H.); Aug. 1–16, 1930, 2 ads., U. R. No. 2122–23. ESSEX: (Allen, 1869); *Adirondack Lodge,* Aug. 15, 1925, 1 ad. (F. Harper); *Blue Ridge Mountain,* Schroon falls, June to Sept. 1926, several (Weber, 1928); *Blue Ridge P. O.,* June to Sept. 1926 (Weber, 1928); *Chilson,* Sept. 1907, 1 larva, N. Y. S. M. No. 615 (62nd Ann. Rep't State Mus., 1909); *Elizabethtown,* M. C. Z. No. 2279 (G. S. Miller); *Keene Valley,* Aug. 26, 1921, 1 larva; *Newcomb* (DeKay, 1842); *North Elba,* Sept. 20, 1927, 1 ad., N. Y. S. M. No. 4737 (Norman Coolidge); between *North Hudson* and *Underwood,* June to Sept. 1926, several (Weber, 1928); *Opalescent river,* July 27, 1927, 1 larva, N. Y. S. M. No. 3926 (Orra P. Phelps); *Paradox lake, Severence,* June to Sept. 1926, common (Weber, 1928); *St Huberts,* Aug. 31, 1921, 1 ad., A. M. N. H. No. 14,539 (C. A. Rogers). FRANKLIN: *McBrides pond,* 1916, 1 larva, M. C. Z. No. 3967 (T. Barbour); *Tupper lake,* Sept. 1915, 1 ad., M. C. Z. No. 4274 (T. Barbour). HAMILTON: *High Rock pond* outlet, near *Seventh lake,* Aug. 17, 1931, 1 ad. HERKIMER: *Mohawk,* 1 spec., C. M. No. 1665 (Dunn, 1926). MONROE: Rare in Monroe co. (Wright and Moesel, 1919). ONEIDA: *Big Woodhull creek,* Roy. Ont. Mus. (Dunn, 1926). ONONDAGA: *Onondaga Valley,* June 5, 1916, 3 ads. (J. R. Slater); *Pompey hill,* 2 juv. (Britcher, 1903); *Syracuse College of Forestry,* nursery, May 31, 1916, 1♂, 2♀ R. S. No. 363 (C. C. Adams). ONTARIO: *Canandaigua lake,* Woodville, Sept. 1, 1932, 1 just trans.; Oct. 8, 1933, 1 ad., U. R. No. 3194; July 13, 1935, 2 ads. ORANGE: *Highland Falls,* 1875 (Mearns, 1898); *Port Jervis* (G. Bump); *Newport,* July 29, 1936, 1 larva, U. R. No. 4076 (Hall and Stone). RENSSELAER: *Troy,* June 7, 1925, 1 ad. ST LAWRENCE: *Oswegatchie,* Oct. 18, 1933 (J. Westman). SARATOGA: *Wilton,* Nov. 5, 1923, 1 ad. (L. Phelps). SENECA: *Interlaken,* Aug. 14, 1924, 1 larva. STEUBEN: *Arkport,* May 14, 1933, 2 ads. (F. L. Coots); *Keuka lake, Willow point,* Oct. 21, 1927, 1 ad., Hobart College (F. G. Trembley). STEUBEN: *Corning,* Je. 24, 1937, 2 ad. SULLIVAN: *Neversink,* June 14, 1935, sev. (Leo Murray). TIOGA: *Berkshire,* Sept. 1857, 1 spec., M. C. Z. No. 4582; 9 spec., M. C. Z. No. 198, 1240, 4577–82; *Richford,* Oct. 11, 1924, 1 ad. (C. Van Deman); 2 mi. N. W. *Richford,* Oct. 11, 1924, 1 ad. female (F. Harper). TOMPKINS: *Cold spring,* Mar. 14, 1903, C. U. (A. H. W.); *Coy glen,* May 12, 1907, 1 spec., U. S. N. M. No. 39404 (A. A. Allen); Apr. 31, 1916, C. U.; July 31, 1932, 1 ad. (N. W. Davis); *Enfield glen,* May 18, 1911, 1 female, C. U.; *Ithaca,* 1887, C. U.; May 27, 1917, C. U. (J. Moesel); *McLean bogs,* May 24, 1922, several (F. Harper); May 27, 1919, several ads. and larvae, N. Y. S. M. No. 8583–84.5 (A. H. W. and S. C. B.); 1922–1925, ads. and larvae, (Leffingwell, 1926); July 16, 1924, 1 larva; July 23, 1932, 35 ads. and larvae; July 26, 1932, 20 ads. and larvae; Aug. 14, 1932, 1 juv.; Aug. 28, 1932, 1 ad., 2 larvae (N. W. Davis); *Michigan hollow,* Apr. 14, 1915, C. U.; *Ringwood,* July 25, 1932, 3 larvae; July 26, 1932, 3 larvae; Aug. 25, 1932, 2 larvae (N. W. Davis); *Six Mile creek,* Oct. 22, 1932, 5 larvae (N. W. Davis); Oct. 31, 1932, 6 ads., 1 larva; *Turkey hill,* Apr. 18, 1920, C. U.; Apr. 31, 1920, C. U. (A. H. W.); Mar. 27, 1921, C. U. (R. R. H.); Oct. 2, 1921, 2 spec., C. U. (A. H. W.); Mar. 15, 1922, C. U. (R. R. H.); Aug. 8, 1923, ads. and larvae, N. Y. S. M. No. 9525 (A. H. W. and S. C. B.). ULSTER: *Lake Mohonk,* Aug. 26, 1927 (J. A. Weber); 2 mi. N. E. of *Montela,* June 19, 1936 (Hall and Stone); *Panther brook, Big Indian valley,* Sept. 1918, 1 ad., A. M. N. H. No. 6151; 1 ad. (Engelhardt, 1919). WAYNE: Rare in Wayne co. (Wright and Moesel, 1919). WARREN: *Adirondack,* 1 spec., U. S. N. M. No. 3842 (Cope, 1889); *Garnet lake,* Aug. 22, 1937 (Van Auken). WYOMING: *Letchworth Park,* May 18, 1932, 1 ad., U. R. No. 2482.

Records too indefinite to be included under counties. *New York* (Boulenger, 1882; Eckel and Paulmier, 1902); *Central New York* (Fowler and Dunn,

1917); *Northern New York* (Baird, 1850); *Catskills*, 4 spec., U. S. N. M. No. 23181, 23183–84, 23191 (E. A. Mearns); *Cayuga Lake basin*, common in ravines (Reed and Wright, 1909; Hamilton, 1932); *New York* to *Alabama* (Cope, 1869).

Condensed Bibliography

Life history and habits. Bishop, 1927, p. 50–51 (*Gyrinophilus porphyriticus*); Cope, 1889, p. 157; Dieckmann, 1927, p. 264; Dunn, 1926, p. 263; Engelhardt, 1919, p. 20–21; Green, 1925, p. 32; Hamilton, 1932, p. 85; Hassler, 1932, p. 307–08; Morse, 1904, p. 112; Noble and Richards, 1932, p. 12; Pope and Noble, 1921, p. 80; Netting, 1928; Reed and Wright, 1909, p. 403; Smallwood, 1928, p. 94; Smith, 1882, p. 729 (*Spelerpes porphyriticus*); Surface, 1913, p. 85 (*Gyrinophilus porphyriticus*); Wright and Haber, 1922, p. 31–32.

Distribution in New York. Allen, 1869, p. 200 (*Salamandra salmonea*); Baird, 1850, p. 287 (*Pseudotriton salmoneus*); Bishop, 1923, p. 66 (*Gyrinophilus porphyriticus*); Bishop, 1927, p. 50–51; Boulenger, 1882 p. 64 (*Spelerpes porphyriticus*); Britcher, 1903, p. 120 (*Gyrinophilus porphyriticus*); Cope, 1869, p. 108; Cope, 1889, p. 157; DeKay, 1842, p. 76 (*Salamandra salmonea*); Dunn, 1918, p. 465 (*Gyrinophilus porphyriticus*); Dunn, 1926, p. 265–66; Eckel and Paulmier, 1902, p. 401; Engelhardt, 1919, p. 20; Fowler and Dunn, 1917, p. 19; Hamilton, 1932, p. 85; Hassler, 1932, p. 95; Hassler, 1932*a*, p. 307–08; Leffingwell, 1926, p. 72; Mearns, 1898, p. 323; Reed and Wright, 1909, p. 403; Smallwood, 1928, p. 94; Weber, 1928, p. 108; Wright and Moesel, 1919, p. 64; Wright and Haber, 1922, p. 32; 62d Ann. Rep't N. Y. State Mus. 1909, p. 99 (*Amblystoma tigrinum*).

PSEUDOTRITON RUBER RUBER (Latreille)

(*Salamandra rubra* Latreille, in Sonnini and Latreille, Hist. Nat. Rep't 1801, 4:305)

Red Salamander

Figures 3*d*, 4*m*, 50–51, 52*a–e*, 53

The red salamander following transformation is one of the most brilliantly marked species. It is conspicuous against any background but, because of its secretive habits, is seldom observed except by those who seek it. The species is widely distributed in the eastern states but is common only in restricted areas.

Description

Size. The transformed individuals I have measured vary in length from 75 to 150 mm. Dunn (1926, p. 276) records a male 146 mm long, a female that had attained a length of 166 mm and the smallest adult as 72 mm long. The specimen last named was probably a recently transformed individual not sexually mature. In a series of young transformed individuals, characterized by the bright coral-red color, the length varied from 75 to 113 mm with 95 mm as the average. A series of old individuals varied from 124 to 150 mm with an average of 135 mm.

Form. The body in recently transformed individuals is rather slender and gracefully proportioned; old individuals become very stout so that the head and legs appear proportionately shorter than in younger specimens.

The head is moderate in size, widest just back of the eyes and rather abruptly tapering to the rounded snout. The paratoid region is only moderately developed and is without conspicuous pits. The gular fold is well developed and extends on the sides of the neck to the level of the eyes. A poorly defined groove runs from the eye back and downward behind angle of jaw where it meets a groove running to the gular fold. The trunk is slightly depressed and provided dorsally and ventrally with a median impressed line. The sides are well rounded. The legs are short and stout with about six and one-half costal folds between the appressed legs. Toes short, four on the front feet, the first shortest, others in order of length, 4-2-3; toes of the hind feet five, the third and fourth of equal length and longest, others 1-5-2. There are 16 costal grooves counting axial and inguinal.

The tail is nearly round in cross section at the base, oval at a point midway to the tip and posteriorly compressed. A low dorsal keel extends to a point opposite the hind margin of the vent. The skin is everywhere smooth to the touch but casual examination with a hand lens reveals the numerous shallow pits distributed over the dorsal surfaces. On the snout above, there is a series of pores on each side lying between the eye and the nostril, a series encircling each eye, a single series along the margin of the lower jaw and two series forming divergent lines on the chin and throat.

The vomerine teeth are entirely behind the inner nares. They are disposed in single rows which originate a short distance beyond the outer margin of the nares, arch inward then backward in straight or slightly divergent lines. They are nearly or quite continuous with the parasphenoid teeth which are disposed in several rows to form separate club-shaped patches. The tongue is boletoid, rather small and strongly extensile.

Color. There are distinct color phases correlated with growth and age which must be considered separately. The ground color of the dorsal surface of recently transformed individuals is a bright coral-red. The lower sides and venter are lighter and flesh-colored, except in the throat region where the heart gives a splash of red and on the belly where the position of the liver is indicated by an elongate brownish patch. Small rounded black spots are scattered

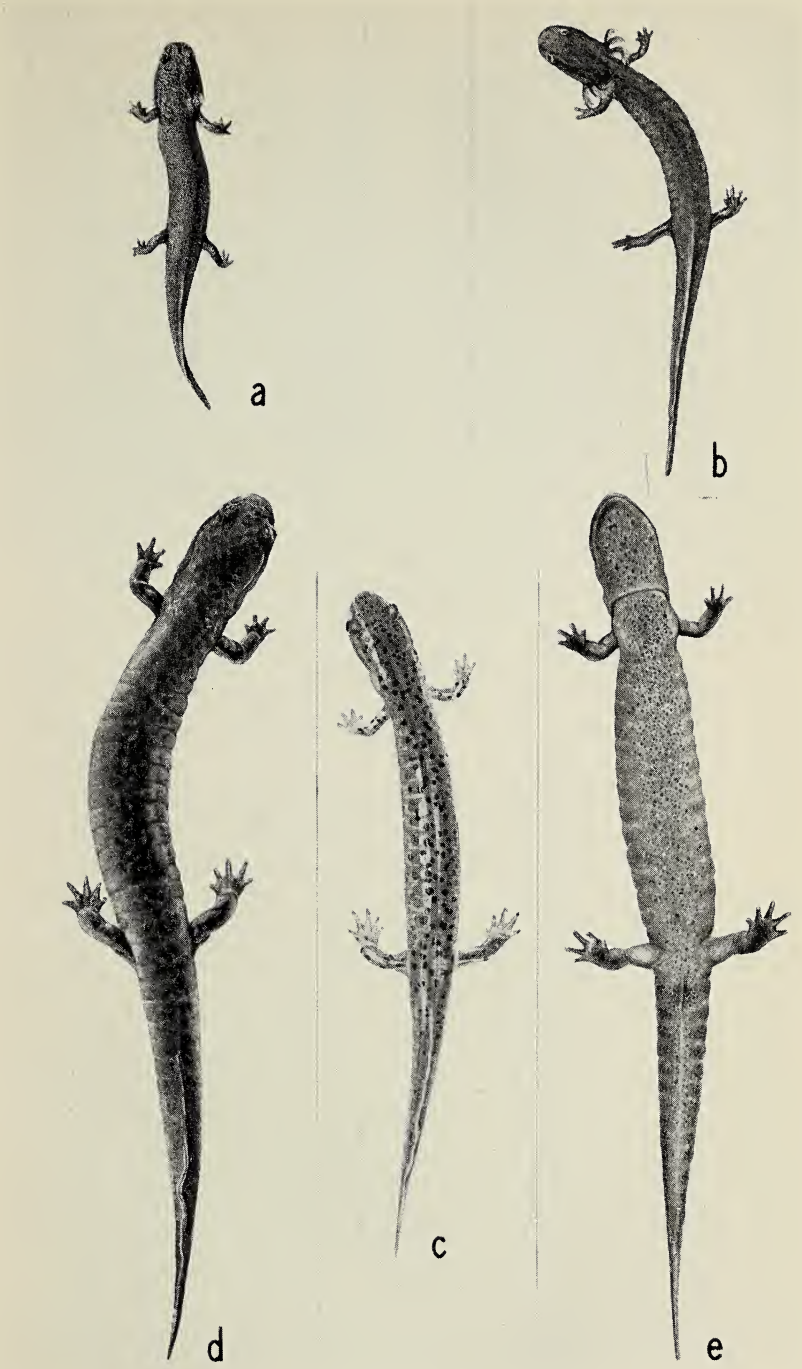


Fig. 50 *Pseudotriton ruber ruber*. a. Young larva, actual length 32 mm, Voorheesville, N. Y., July 7, 1922. b. Mature larva, actual length 90 mm, Voorheesville, N. Y., Apr. 5, 1924. c. Recently transformed, actual length 116 mm, Voorheesville, N. Y., Nov. 4, 1922. d. Adult female, actual length 155 mm, Voorheesville, N. Y., Apr. 27, 1923. e. Adult female, actual length 150 mm E. K. O'B. and S. C. B., del.

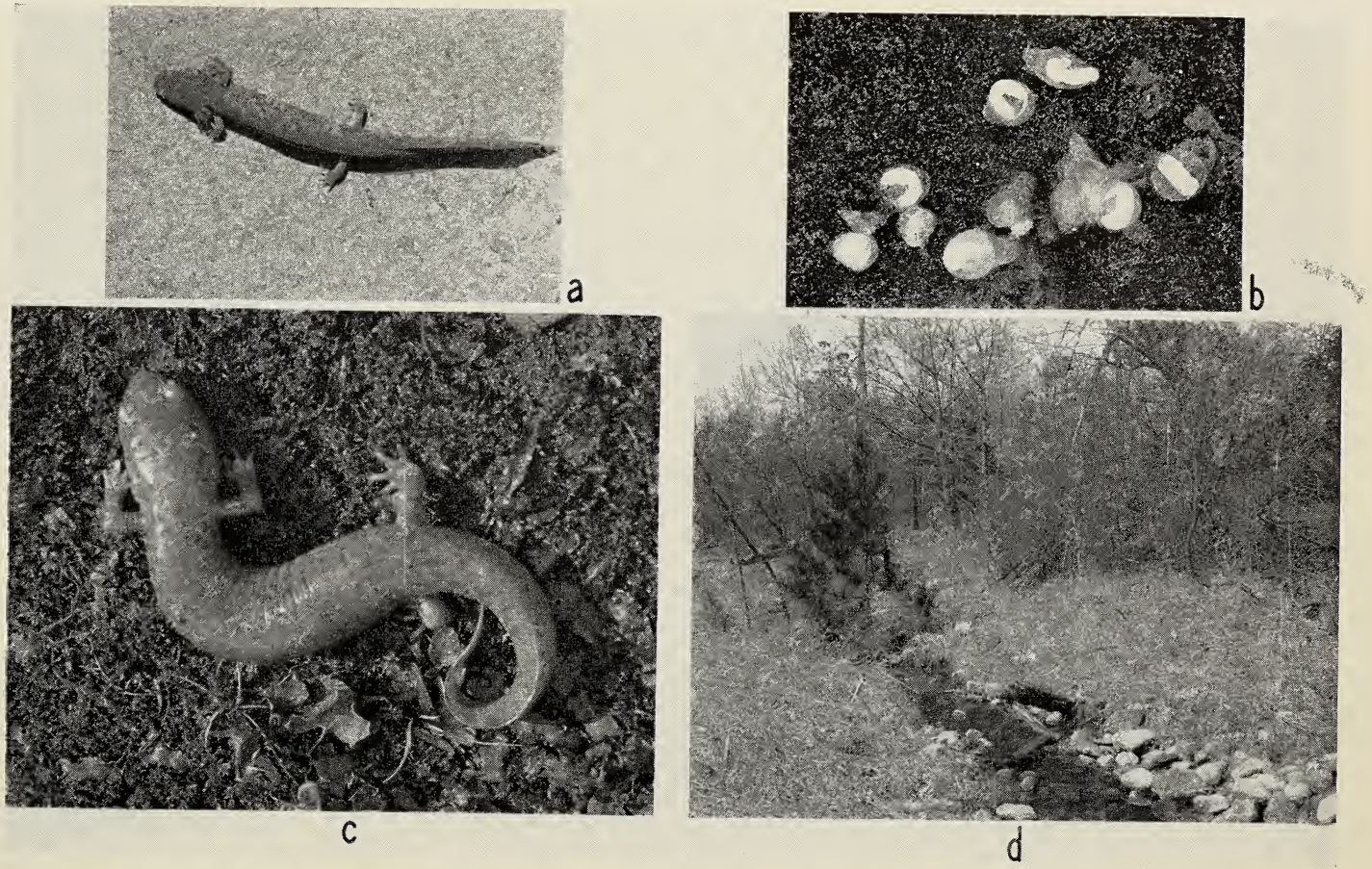


Fig. 51 a. *Pseudotriton ruber ruber*. Full-grown larva, Voorheesville, N. Y., Mar. 26, 1925. Actual length 100 mm. b. Eggs of *P. ruber ruber*, attached to the lower surface of a flat stone. Part of a cluster of 72 found Oct. 3, 1924, and photographed Nov. 10. c. Adult from Voorheesville, N. Y., Mar. 26, 1925. With age the dark spots spread and fuse and the ground color becomes deep purplish brown. d. Spring stream near its source at the foot of the Helderberg escarpment, Albany Co., N. Y. Habitat of *P. r. ruber* and *Gyrinophilus p. porphyriticus*.

thickly over the dorsal surface of the head, back and basal half of the tail. The spots are more widely separated on the upper half of the sides and are absent on the lower sides, the venter and terminal half of the tail. The chin may bear a narrow line of black. The newly transformed individuals are slender and more delicately molded than the older members of its kind and there is a translucent character to the skin which is also lost with age.

The more somber colors of age replace the brighter hues of youth but the change is a gradual one. The rounded black spots spread and fuse and richer tones of purple and brown replace the coral-red. Small flecks of pigment spot the lower sides and venter and the chin is marked with a dark band. The ground color of the belly becomes salmon-red, darker between the costal grooves and impressed vertical lines of the tail, and somewhat lighter along the midventral line of the tail, the lower surface of the legs and across the gular fold.

The following description from life is based on an adult female 143 mm long taken April 5, 1924, at Voorheesville, N. Y. The general ground color is coral, bright on the sides and venter but more or less obscured above both by the large rounded blue-black spots of pigment and the suffused pigment that lies between the larger spots. The large spots are rather regularly distributed above but on the head, legs and sides of the body and tail the pigment spots are smaller. An area on the snout and above each eye has the ground color lighter than the rest of the body. The venter is lightly pigmented with small flecks of brown. These spots are thicker on the throat and between the fore legs and the lower lip is almost black. The under sides of the legs and feet are flesh color and quite free from pigment. The ovarian eggs at this date are exceedingly small.

Sexual differences. Sexual differences are not well marked externally but the females may be recognized when they are carrying well-developed eggs for the yellow of the yolk shows through the skin of the belly and outlines the ovaries as elongate patches, one on either side just in front of the hind legs. The largest specimens recorded are females but whether or not females in general are larger than males has not been determined.

Activities of the Breeding Season

The egg-laying season. Until a considerable number of separate egg complements of the red salamander have been discovered, knowledge of the extent of the egg-laying season must depend to a large degree on the dissections of females. A single lot of eggs

was found October 3, 1924, in a tamarack swamp near Voorheesville, N. Y. (Bishop, 1925). The eggs were fastened to the lower surface of a large flat stone buried deep beneath the sod at the margin of a cold spring, and so disposed that they received the water as it bubbled from the ground. The stone itself was about six inches below the water surface of the spring. At the time of discovery the eggs were well advanced in development and, considering the temperature of the water, they may have been laid as early as the middle of September. This date may be considered as marking the beginning of the egg-laying season in the North and is perhaps exceptionally early, for many females taken later in the season were heavy with eggs. On November 10, 1924, a female which still retained the brilliant red color, indicating recent transformation, was found to be fully distended with eggs. It seems probable that the old and fully mature individuals may deposit their eggs rather early in the season and that the time of egg laying for young adults depends on the time of transformation. Not all young adults lay the first season of transformation and some may never deposit the eggs while in the bright red color stage.

In November 1930, Dr V. C. Twitty and Dr Crawford Hutchinson collected in the vicinity of Woodstock, Ulster county, N. Y., and found a total of 290 eggs of the red salamander attached to the lower surface of stones in springs. The embryos were in various stages of development indicating that the eggs represented the complements of several females and had been deposited at different times. Some were at or near the hatching point while others were much less advanced. While no record of the date was kept, Doctor Hutchinson believes the collections were made during the first week in November.

These records lend considerable support to the theory that in the northern parts of its range, the red salamander deposits its eggs in the late fall and early winter months. It does not, of course, discredit the contention that farther south, the eggs may be deposited later in the winter or early in the spring.

An old dark female collected December 3, 1923, had deposited her eggs some time previous to that date and the ovaries contained only very minute ova, the next season's complement. The eggs continue small during the spring and summer and enlarge rather rapidly during the fall months. In the latitude of Washington, D. C., the season is apparently later. M. K. Brady dissected females in December and found mature eggs in the ovaries and, on February

10, 1915, discovered a batch of eggs which he believed to belong to this species.

Ditmars (1905, p. 177) reported that "the eggs are deposited early in the spring in the deeper pools of brooks." Hallowell, (1856, p. 101) says that females taken near Philadelphia, Pa., had developed eggs in the ovaries April 28th.

The egg mass. The eggs are attached to the lower surface of a support in water. In general they have the appearance of the eggs of *Eurycea b. bislineata* but are larger, disposed in little clusters of about a dozen and spread over an area several inches across. In the lot found October 3, 1924 there were 72. The attachment stalk is also longer and slimmer than in *E. b. bislineata* and when the support is lifted from the water the eggs hang together in clusters an inch below the surface. To facilitate observation on the development of the eggs, the stone to which they were attached was transferred from its resting place to the bed of the spring and supported on smaller stones. This procedure resulted in the loss of a considerable number of eggs through the activity of other salamanders and by fungus.

The eggs found by Twitty and Hutchinson were also disposed in groups, four clusters containing 48, 35, 18 and 14 eggs respectively. To the lower surface of a single large rock a total of 156 eggs was found, grouped in clusters of 65, 35, 34, 12 and 10 and probably representing the complements of at least two females.

Development

The egg and its envelops. At the time of discovery the embryos were well advanced and, judging by their size, the egg must have been about 4 mm in diameter. There was no indication of pigmentation, the color being uniform yellowish white. The envelops are much as in *Eurycea b. bislineata* and consist of a thin vitelline membrane which closely surrounds the egg or embryo, a middle layer inclosing a thin clear jelly and an outer, tougher covering which is drawn out to form the stalk and attachment ring. The egg and its envelops have a total diameter of about 6 mm. In two instances two embryos were inclosed by common envelops but their combined size was not noticeably greater than the single ones. During development of the embryo the envelops stretch considerably to accommodate the growing young and the outer layers present a distinctly striated appearance.

The incubation period. The eggs discovered October 3, 1924, were so far advanced in development that, considering the temperature of the water, they may have been deposited as early as the middle of September. A few individuals under observation in the laboratory hatched November 12th, prematurely, I believe, for the envelops had been disturbed when the eggs were removed from the stone. Those in the field continued to hatch until November 28th, but had also been inadvertently shaken loose from the support. These figures give a period of incubation of from 58 to 74 days for individuals hatched under conditions not exactly normal and it is probable that several weeks might be added to the period if the eggs had never been disturbed.

Body divisions were evident in the embryo at the time of discovery and even the gill buds were indicated by a considerable development of tissue. Between October 3d and November 8th there was considerable advance, but in this period of 36 days the change was not greater than that observed in *Hemidactylium scutatum* in 14 days. Chromatophores were distributed over the upper surface of the head, trunk and tail and on the upper sides. The gills were represented by elongate buds, the third on each side with a short branch. The buds of the fore legs were a little longer than the gills and lightly pigmented above. The buds of the hind legs were simple, rounded protuberances. The eyes were scarcely indicated. The yolk-distended abdomen comprised the bulk of the body. The tail keels extended above and below to the base.

The newly hatched larvae. The following descriptions pertain to larvae hatched, as above noted, under conditions which may not be regarded as strictly normal. The length varies from 13 to 15 mm. They are pigmented as follows: on the head to the lower level of the eyes; on the trunk, the entire dorsal surface and the sides to the level of the legs; on the tail, both dorsal and lateral surfaces are pigmented and a few scattered chromatophores are present on the keels. The gills, buds of the legs and ventral surfaces of the head and trunk are dull yellow and free from pigment.

The gills are fairly well developed and provided with a few short filaments. The fore legs are elongate buds directed backwards; the hind legs are less advanced. The eyes and mouth are rudimentary and incapable of functioning. The yolk mass is large and pendulous and the tail comprises about three-tenths of the total length.

The larvae lengthen rather soon after hatching but the appendages show little advance in development for a considerable period. As

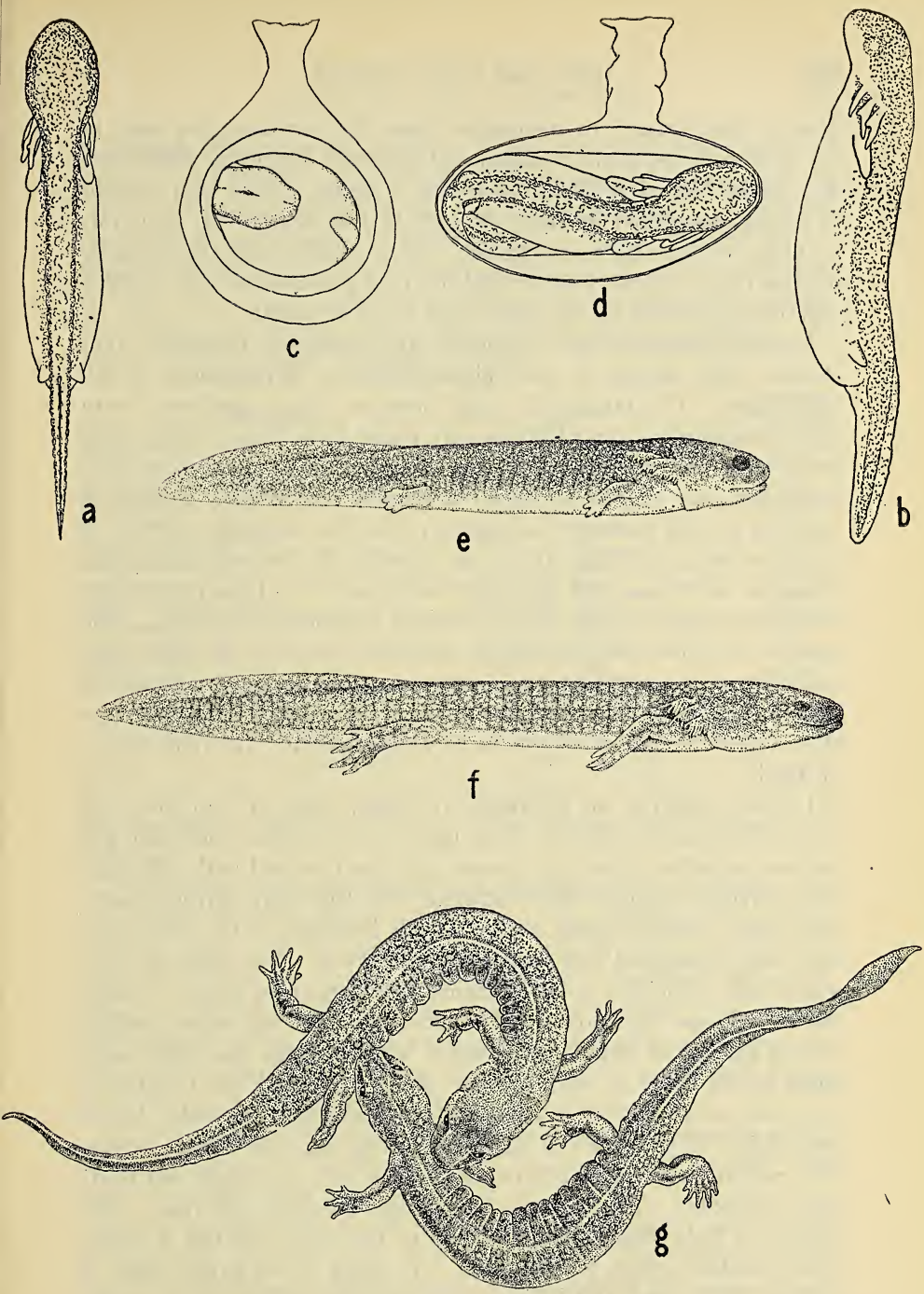


Fig. 52 a. *Pseudotriton ruber ruber*. Larva at hatching. Eggs were removed from lower surface of stone and larvae probably hatched prematurely. Voorheesville, N. Y. Nov. 12, 1924. Actual length 13 mm. W. J. S., del. b. Same, side view, W. J. S., del. c. Encapsuled embryo, Oct. 3, 1924, W. J. S., del. d. Encapsuled embryo showing elongated egg-envelops, Nov. 8, 1924. W. J. S., del. e. Larva, Feb. 11, 1925. Actual length, 21 mm. H. E. R., del. f. *Gyrinophilus porphyriticus porphyriticus*, young larva, Voorheesville, N. Y., April 5, 1924. Actual length, 25 mm. H. E. R., del. g. Adult male and female in mating activities. Voorheesville, N. Y., Oct. 8, 1924. H. P. C., del.

soon as the larvae free themselves from the envelops they sink to the bottom of the pool or stream and by active wriggling make their way under bits of rubbish, old leaves or stones. Here they remain in hiding, supported by the yolk and, in fact, buoyed up by it for, as often as not, they rest upside down. During the cold winter months they are quite inactive and the vital processes are so retarded that little decrease in the yolk mass is to be noted.

Larvae hatched in late November and examined December 12th showed little change in size, pigmentation or development of the appendages. On January 8, 1925, however, when specimens were again examined in the field they were found to be 18 mm long. The limbs were still represented by the elongated buds and the gill filaments had only slightly increased in number and length. Pigmentation had greatly increased in intensity, the line marking the limit of color on the sides being in strong contrast to the yellowish white abdomen which was still distended with yolk. On January 25th the larvae were again examined and showed considerable advance. The toes of the front feet showed as separate members, the gills were well fringed and pigmented. These larvae had attained a length of 20 mm and swam actively about when disturbed. The yolk was still evident though greatly reduced and apparently the only source of food.

Larvae measured on February 11, 1925, were 21 mm long and were developed as follows: front legs with the elbow indicated and the toes separate; hind legs shorter than the fore and with only four toes developed and the fifth indicated; the legs were directed backward; tail broadly keeled almost to the insertion of the hind legs; eyes well pigmented and apparently functional. The gills are provided with a double row of filaments well pigmented above. Under the microscope the ground color above is yellowish white overlaid with a pattern of light brown tinged with lavender and with many small round flecks of black pigment which may mark the position of the spots which are so conspicuously developed in the older larvae and adults. If the colors of the larvae in this stage were more intense they would be those of adults which have lost the bright red color and replaced it with tinges of brown and lavender and blue. The head is a little darker than the rest of the body and has a rather broad median stripe to the snout. In front of each eye there is another short band and between this and the median one is a narrow light area which gives the larvae a head pattern something like that of the young *Gyrinophilus*.

Length of the larval period. When a considerable number of larvae is collected at the same locality, at essentially the same season of the year and selected according to size, they fall into groups which represent approximately the annual growth. In the Albany, N. Y., region, young of the year in the spring months, March to July, vary in length from 22 to 25.5 mm; in July from 25 to 27 mm. These have obviously hatched during the fall or winter preceding. My records of these small specimens follow:

LOCALITY	DATE	LENGTH IN MM
Voorheesville, N. Y.	Feb. 11, 1925	21.0
Voorheesville, N. Y.	Mar. 13, 1928	23.5
Voorheesville, N. Y.	Mar. 13, 1928	25.5
Voorheesville, N. Y.	Apr. 5, 1924	22.0
Voorheesville, N. Y.	Apr. 5, 1924	23.0
Voorheesville, N. Y.	Apr. 5, 1924	23.0
Voorheesville, N. Y.	Apr. 5, 1924	25.0
Voorheesville, N. Y.	Apr. 15, 1924	24.0
Voorheesville, N. Y.	Apr. 28, 1924	23.0
Voorheesville, N. Y.	Apr. 28, 1924	23.0
Voorheesville, N. Y.	June 4, 1924	25.0
Voorheesville, N. Y.	July 7, 1924	25.0
Voorheesville, N. Y.	July 31, 1924	27.0

Taking into account a probable variation in hatching time and growth rate, it is evident there is a gradual increase in size of the larvae from the 21 mm specimen measured in February to the 27 mm specimen collected in July. The average for the series is 23.8 mm.

These larvae, hatched during the preceding fall or winter, may be regarded as five to seven months old. The individuals composing the next group will be found to vary in length from 42 to 60 mm and average 51.1 mm at an age of from 17 to 19 months. In a third group the variation is from 65 to 78 mm, the average 71 mm. The individuals composing the fourth group vary from 81 to 100 mm and average 88.5 mm. These larger individuals are approaching transformation at an estimated age of 41 to 43 months.

The estimates presented above are based on measurements of 75 larvae all taken at Voorheesville, N. Y., from April to July, and should be regarded as tentative.

This grouping does not take into account the considerable number of individuals that transform at a much smaller size, from 75 to 80 mm, and it remains to be determined whether these specimens represent slower growing individuals of the same age or individuals that are transforming when considerably younger than is usual for the species.

In a preliminary account of the life history of the red salamander (Bishop, 1925) I estimated that the larvae matured in about three years. In the light of more recent studies based on additional material, I am convinced that my estimate was too low and that about three and one-half years are normally required to complete development to transformation. It must be remembered that these estimates are based on examination of specimens from a single restricted locality near Albany, N. Y., and that we are dealing with a species near the northern limits of its range.

The larvae in their development to maturity undergo color changes which may be summarized as follows. In the newly hatched larva the ground color is dull white with chromatophores of brown and black scattered over the dorsal surface. In the course of a few weeks, tinges of lavender appear between the darker fleckings but are soon lost in the general darkening of the ground color which changes from dull white to brownish. The dark spots become more intense with age and the brownish ground-color spreads to cover the sides, the upper surfaces of the limbs and the tail fins. The brownish ground-color is gradually replaced by red and some larvae only 60 mm long are as bright as individuals recently transformed; others retain the brownish ground-color until near transformation. Noble and Richards (1932, p. 11) have written of this salamander that when larvae are precociously metamorphosed by use of thyroid extracts, the ground color is yellow and not red but when these individuals were given subcutaneous implants of pars anterior of toad pituitary, the experimental animals assumed a reddish tinge not seen in the controls. From their experiments they conclude: "It seems probable that in the normal development of the salamander it is the release of a quantity of anterior pituitary hormone, initiating metamorphosis, which brings about the assumption of adult red color at this time." This is interesting and possibly true but it does not take into account the considerable number of larvae which attain the bright red color a year or so in advance of transformation.

The mature larvae. I have collected transformed individuals only 75 mm long and have measured larvae that had attained a length of 100 mm. Dunn (1915, p. 29) reports having found a larva 110 mm in length and an adult only 72 mm long. The following description is from a living example 93 mm in length. The ground-color is a light reddish brown with distinct tinges of orange along the base of the upper tail fin and on the snout between the eyes. The pigment spots are round and fairly large on the trunk, smaller and

closer together on the head and legs, and fine on the distal half of the tail. The gills are well pigmented but the color is tempered by the red of the blood. The dorsal tail fin originates opposite the posterior end of the vent; the ventral fin is confined to the posterior half. The pupil of the eye is black and slightly elongated horizontally, the iris brassy with a dark bar across the center. At the time of transformation the gills and tail fins are lost in a comparatively short time and bright coral-red replaces the reddish brown ground color of the larva.

Not all larvae retain the brownish ground color until the time of transformation. I have found a few bright red larvae only 60 mm in total length and a considerable number somewhat larger.

Transformation. Specimens undergoing gill reduction and exhibiting other evidences of approaching transformation are limited, in my collections, to specimens taken in April, May and June. The records and measurements follow:

Voorheesville, N. Y.	April 6, 1927	100 mm
Voorheesville, N. Y.	May 5, 1924	89 mm
Voorheesville, N. Y.	June 4, 1922	91 mm
Voorheesville, N. Y.	June 4, 1922	100 mm
Voorheesville, N. Y.	June 13, 1922	82 mm

The average length of these five specimens is 92.4 mm. Dunn (1915, p. 29) described the transformation of two individuals in late May and early June at Haverford, Pa. Individuals in the bright red stage have been found from April through December. My records include specimens from Voorheesville, N. Y., and a few other localities.

LOCALITY	DATE	NO. SPEC.	LENGTH IN MM	SOURCE
Voorheesville, N. Y.	Apr. 4, 1923	1	....	S. C. B.
Voorheesville, N. Y.	Apr. 13, 1926	1	....	S. C. B.
Voorheesville, N. Y.	Apr. 16, 1927	1	....	S. C. B.
Voorheesville, N. Y.	Apr. 20, 1923	1	....	S. C. B.
Tuxedo, N. Y.	May 24, 1924	1	76	Hassler
Suffern, N. Y.	May 26, 1924	1	75	S. C. B.
Voorheesville, N. Y.	June 4, 1922	1	....	S. C. B.
Voorheesville, N. Y.	June 11, 1925	1	....	S. C. B.
Voorheesville, N. Y.	June 13, 1927	1	....	S. C. B.
Voorheesville, N. Y.	July 17, 1922	1	90	S. C. B.
Palisades Ins. Park	July 23, 1922	2	....	.....
Quaker Bridge, N. Y.	Aug. 3, 1922	1	....	Alex.
Voorheesville, N. Y.	Oct. 3, 1924	1	....	S. C. B.
Voorheesville, N. Y.	Nov. 4, 1922	1	84	S. C. B.
Voorheesville, N. Y.	Nov. 4, 1922	1	90	S. C. B.
Voorheesville, N. Y.	Nov. 8, 1924	1	....	S. C. B.
Voorheesville, N. Y.	Nov. 10, 1924	1 ad. ♀	....	S. C. B.
Voorheesville, N. Y.	Dec. 3, 1922	1	112	S. C. B.
Voorheesville, N. Y.	Dec. 10, 1927	1	....	S. C. B.

Development to maturity. As before mentioned in the paragraph dealing with the egg-laying period, a bright red female found November 4, 1924, was distended with large eggs. If we are correct in our assumption that, in the Albany region, transformation ordinarily takes place in April, May or June, this individual may have reached sexual maturity in from five to seven months. There is, of course, the possibility that it transformed the spring of the year before and attained sexual maturity 17 or 19 months after transformation. The fact that other specimens of equal or greater size, taken in November and December, had not yet matured their eggs might indicate that the latter assumption were the correct one.

Habits

The adults are rarely if ever found abroad during the day but hide in the stream bottom or beneath some sheltering object, sometimes a considerable distance from water. The larvae, on the other hand, while they do not often attract attention in the open, may be found foraging by day in the thick patches of water weeds, cress or *Chara,* and may be captured by dip net or the simple process of pulling weeds by the handful.

Often the adults wander about at night when the weather is warm and moist and, if overtaken by daylight, seek refuge beneath the nearest shelter.

This is not a particularly active species and seldom makes strenuous attempts to escape until grasped.

Food. Young larvae feed upon small aquatic organisms such as Entomostraca, larvae of insects and worms. The older salamanders capture worms, insects and other salamanders. In captivity they will accept earthworms and bits of raw meat. Quantities of rubbish are ingested with the food and an examination of the contents of the intestines reveals bits of leaves and sticks, sand, muck and small stones and the needles of the hemlock. From the mouth of a specimen taken June 27, 1925, at Fallen Rock camp, Quicksand, Ky., I took three beetles which were identified as *Amara impuncticollis* Say. A specimen taken at Voorheesville, N. Y., had eaten the terrestrial red-backed salamander.

Surface (1913, p. 103) says, "The food found in 59 stomachs consisted of earthworms, snails, slugs, spiders, thousand-legged 'worms,' numerous forms of insects and their larvae, and plant material." Among the vertebrates taken were four undeveloped salamanders, one *Plethodon cinereus* and one frog skin.

Habitat

The red salamanders are found in greatest numbers in clear, cold springs and streams. I have never found them in large streams except near the headwaters but the smallest trickle, if it is constant and flows among stones and moss, is sufficient for a hiding place. They occur not only in streams that flow through wooded ravines and swamps but in open fields and meadows and in the hillside springs that break out of the ground and spread to form boggy areas of considerable extent.

The larvae are strictly aquatic until the time for transformation approaches, when they are sometimes to be found in excavations beneath stones or logs at the edge of the water and ready at the slightest disturbance to slip back into it. The adults are entirely aquatic only during the coldest months of the northern winter. During the summer and fall they venture from the water and hide by day under cover of logs, loose bark or stones. Both the old adults and those recently transformed forsake the water and sometimes select the same retreat for a hiding place. On April 20, 1923, two specimens were found beneath a concave stone by the side of a small stream. On May 6, 1923, an old dark male was exposed when a dry stone in a pasture was overturned. A bright red individual was found on June 4, 1922, occupying a shallow excavation beneath a stone in a meadow and shared the shelter with a dead specimen of *Plethodon cinereus*. All the specimens above mentioned were found near Voorheesville, N. Y., about 14 miles west of Albany. On one occasion, on June 27, 1925, I found (near Quicksand, Ky.) a mature specimen beneath a section of log which lay on the surface of the perfectly dry soil fully 100 feet from the nearest water. But these are exceptional cases. By far the greater number are found in water or in excavations that communicate with the water by definite passages. Sometimes extensive burrows are driven through the soft, yielding soil and are kept open by frequent use. Waters that harbor *Pseudotriton r. ruber* are also frequented by *Gyrinophilus p. porphyriticus, Eurycea b. bislineata* and *Desmognathus f. fuscus* but the two last-named species may also be found in a variety of situations not suited to the red salamander. The requirements and preferences of the red salamander are more nearly those of *Gyrinophilus p. porphyriticus* but in a stream where both are to be found the small larval red salamanders are likely to resort to the weedy sections and the larval *Gyrinophilus* to the shelter of the stones on the bottom. The adult red salamander will force its way through black muck of the swamp to a suitable hiding place beneath a log

or stone; the adult *Gyrinophilus* more often remains in the stream itself and hides under stones that are in or near the water.

Sherwood (1895, p. 30) writes of this species, "I captured several adults . . . under turfy soil overflowed by a brook, and some under stones in a brook. All during May and June, I have heard of their being turned up by the plow and assume that later in the season they become more terrestrial."

Ditmars (1905, p. 176) says, "the adults are semiaquatic, living in the beds of clear and cold brooks under flat stones or in immediate proximity to water, into which they quickly make their way when disturbed. They may be sometimes found hiding under the luxuriant moss that covers rocks adjacent to mountain streams where their brilliant color is in vivid contrast to their surroundings."

Abbott (1884, p. 344) reports, "This large red salamander also has a clear, bell-like note, which, though frequently heard, is not usually recognized."

"It is a true hylodes note . . . They call, whistle, or give tongue, as you choose to express it, only in spring and at the time when the females are depositing their eggs. This, at least, is my impression." The call heard by Abbott was doubtless a true "hylodes note," as he expressed it, and probably came from a *Hyla*.

Remarks

Although this species has been known since 1801, much remains to be learned of the details of its life history. Nothing has been published concerning its mating habits under natural conditions and the eggs have been described but once (Bishop, 1925). Dunn (1915) presented some notes on transformation and in 1926 summarized practically all that was known.

Range

From Albany county, N. Y., to northern Georgia westward to Ohio, Kentucky, Tennessee and Alabama.

Distribution in New York

General. Hudson valley from Albany county southward on both sides of the river, Staten Island and Cattaraugus county. Absent from Long Island.

Fig. 53 New York localities for *Pseudotriton ruber ruber.*

Specific records. ALBANY: *Albany,* May 7, 1835, several (Eights, 1835); *Thacher Park,* Apr. 24, 1915 (Reynolds); Apr. 1915 (Bishop, 1923); Oct. 4, 1924, 1 ad.; *Voorheesville,* June 4, 1922, 1 ad., 7 larvae, N. Y. S. M. No. 9210; June 10, 1922, 1 larva, N. Y. S. M. No. 9220; June 13, 1922, 2 juv., N. Y. S. M. No. 9239–40; July 7, 1922, 1 juv., 5 larvae; July 17, 1922, 1 ad., 1 juv.; Oct. 28, 1922, 1 ad., 1 larva, N. Y. S. M.; Nov. 4, 1922, 3 ads., N. Y. S. M. No. 9370; Dec. 3, 1922, 1 ad., 1 larva; (Records June–Dec. 1922, Bishop, 1923); Apr. 4, 1923, 1 ad.; Apr. 10, 1923, 1 ad.; Apr. 14, 1923, 1 ad.; Apr. 20, 1923, 2 ads.; Apr. 27, 1923, 2 ads.; May 6, 1923, 1 ad.; July 31, 1923, 2 larvae, N. Y. S. M. No. 9522 (A. Wolf); Oct. 4, 1923, 1 spec.; Dec. 3, 1923, 2 ads., N. Y. S. M. No. 9445; Feb. 10, 1924, 1 larva; Mar. 1, 1924, 5 larvae, N. Y. S. M. No. 1421 (S. C. B. and W. J. S.); Mar. 8, 1924, 4 larvae, N. Y. S. M. No. 1450 (S. C. B. and W. J. S.); Apr. 5, 1924, 4 ad., 11 larvae; Apr. 15, 1924, 1 ad., 4 larvae (S. C. B. and W. J. S.); Apr. 28, 1924, 2 larvae; May 5, 1924, 1 larva; June 4, 1924, 1 larva; Oct. 3, 1924, several ads. and larvae; Nov. 2, 1924, 6 larvae; Nov. 8, 1924, 1 ad.; Nov. 10, 1924, 1 ad.♀; Nov. 12, 1924, 6 larvae; Feb. 11, 1925, 1 larva; Mar. 13, 1925, 1 larva; Mar. 26, 1925, 1 larva; May 18, 1925, 1 ad.; June 11, 1925, 1 ad., several larvae; Aug. 27, 1925, 1 ad.; Sept. 25, 1925, 1 ad., 2 larvae; Apr. 13, 1926, several spec. (S. C. B., W. J. S. and H. H. Cleaves); Apr. 29, 1926, 2 ads., 1 larva (S. C. B. and B. S. Bronson); Dec. 9, 1926, 1 larva (S. C. B. and W. J. S.); Apr. 16, 1927, several ads., juv., and larvae (S. C. B. and B. S. Bronson); Apr. 30, 1927, 1 ad., 1 larva; July 29, 1927, several ads. and larvae (S. C. B. and T. I. Storer); Sept. 21, 1927, 1 larva; Oct. 19, 1927, 1♂, 1♀, 2 larvae; Dec. 10, 1927, 1 juv.; Mar. 13, 1928, 6 larvae (S. C. B. and W. J. S.); Oct. 28, 1928, 1 ad., 1 larva. CATTARAUGUS: *Allegany State Park,* Aug. 3 1922, 2 spec., N. Y. S. M. No. 3325 (Bishop, 1927); junction of Limestone and Red House roads, 1928, 1 ad. (Shadle). DUTCHESS: *Poughkeepsie,* Apr. 6, 1878 (W. H. Smith, 1882). GREENE: *Coxsackie,* 1851 (5th Ann.

Rep't State Cab. Nat. Hist., 1852). ONONDAGA: *Pompey hill* (doubtful record) (Britcher, 1903). ORANGE: *Greenwood Lake glens,* Brook. Mus. No. 746 (Dunn, 1926); *Highland Falls,* 1 ad., U. S. N. M. No. 23293 (Mearns); *Mountainville,* June 12, 1920, 1 ad., A. M. N. H. No. 12,874; June 13, 1920, 1 larva, A. M. N. H. No. 12,867; *Palisades Interstate Park,* Bear Mt. section, summer 1923, 2 spec., A. M. N. H. No. 24,207–8; Car pond, July 10, 1919, 1 ad., R. S. No. 2281 (J. P. Moore); Kanohwahke lakes, July–Aug. 1923 (G. S. Myers, 1930); Tiorati brook, Aug. 11, 1923, 1 spec., A. M. N. H. No. 24,222 (G. S. Myers); *Port Jervis* (G. Bump); *Tuxedo,* May 24, 1924, 1 ad., A. M. N. H. No. 21,046 (W. J. Hassler); *West Point,* June 11, 1911, 1 spec., A. M. N. H. No. 16,821 (C. Schaeffer); 1 ad., M. C. Z. No. 5648. RICHMOND: *Staten Island* (Davis, 1884; Cope, 1889; 1 spec. A. N. S.); June 1895, 3 ads. (W. T. Davis); Aug. 17, 1917, 1 ad. (W. T. Davis); (Fowler and Dunn, 1917); Apr. 2, 1926, 1 ad. (R. Ostrander); 1931 (Wilmott, 1933); *Horseshoe Spring,* Apr. 24, 1909 (Skinner, 1910). ROCKLAND: *Suffern,* Apr. 10, 1920, 1 larva, A. M. N. H. No. 7468 (K. P. Schmidt); May 26, 1924, 1 ad., 2 larvae, N. Y. S. M. No. 1516. ST LAWRENCE: *Rossie,* 1851 (doubtful record) (5th Ann. Rep't State Cab. Nat. Hist., 1852). ULSTER: *Lake Minnewaska,* July 1907, 1 ad. (W. T. Davis); *West Shokan,* July 29, 1909, 3 spec., A. M. N. H. No. 2349-50 (A. L. Treadwell); *Woodstock,* 3 juv., U. S. N. M. No. 61115-19 (E. Uhlenhuth); Nov. 1930, ads. and eggs (Twitty and Hutchinson). WESTCHESTER: Brook near *Silver lake* (Deckert, 1914).

Records too indefinite to be placed under counties. *New York* (Baird, 1850; Boulenger, ♂ ♀ and larvae, 1882); distributed over eastern district of N. A. from *Maine* to *Minnesota* and to *Texas* and *Florida* (Cope, 1869); one of our commonest species (DeKay, 1842); *Catskill Mountains,* 1880–1882 (Bicknell, 1882); *Hudson Highlands,* Feb. 14, 1876 (Mearns, 1898); June 23, 1898, 2 spec., A. M. N. H. No. 3740–1 (E. Smith); *Long Island,* 2 spec. A. M. N. H. No. 2480–83 (N. Pike); *Palisades Interstate Park,* July 23, 1922, 2 spec., A. M. N. H. No. 17,103–4.

CONDENSED BIBLIOGRAPHY

Life history and habits. Abbott, 1884, p. 344 (red salamander); Bishop, 1925, p. 385–89 (*Pseudotriton ruber*); Bishop, 1927, p. 51–54 (*Pseudotriton ruber ruber*); Ditmars, 1905, p. 176–77 (*Spelerpes ruber*); Dunn, 1915, p. 28–30 (*Spelerpes ruber*); Dunn, 1926, p. 272–81 (*Pseudotriton ruber ruber*); Hallowell, 1856, p. 101 (*Pseudotriton ruber*); Mearns, 1898, p. 324 (*Spelerpes ruber*); Sherwood, 1895, p. 30; Surface, 1913, p. 101–03.

Distribution in New York. Baird, 1850, p. 286 (*Pseudotriton ruber*); Baird, 1852, p. 22; Bicknell, 1882, p. 124 (*Spelerpes ruber*); Bishop, 1923, p. 67 (*Pseudotriton ruber ruber*); Bishop, 1925, p. 386; Bishop, 1927, p. 54; Boulenger, 1882, p. 63 (*Spelerpes ruber*); Britcher, 1903, p. 121; Burt, 1931, p. 200 (*Pseudotriton ruber ruber*); Cope, 1889, p. 175 (*Spelerpes ruber*); Davis, 1884, p. 13; Deckert, 1914; DeKay, 1842, p. 80 (*Salamandra rubra*); Eckel and Paulmier, 1902, p. 401–02 (*Spelerpes ruber*); Eights, 1835, p. 130 (*Salamandra rubra*); Fowler and Dunn, 1917, p. 19 (*Spelerpes ruber*); Holbrook, 1842, p. 35 (*Salamandra rubra*); Hough, 1852, p. 24; Mearns, 1898, p. 324 (*Spelerpes ruber*); Myers, 1930, p. 100 (*Pseudotriton ruber ruber*); Noble, 1927, p. 3 (*Pseudotriton ruber*); Noble, 1931, p. 479; Sherwood, 1895, p. 30 (*Spelerpes ruber*); Skinner, 1910, p. 226; Smith, 1882, p. 728; Wilmott, 1933, p. 163 (*Pseudotriton ruber*).

General. Cope, E. D. The Batrachia of North America, Bul. 34, U. S. Nat. Mus. 1889, p. 172, pl. 29, figs. 1–5; pl. 30, figs. 1–6; pl. 31, figs. 1–6; pl. 32, figs. 1–3; pl. 35, figs. 7–10; pl. 40, figs. 1–2; pl. 45, fig. 6; pl. 48, fig. 16 (*Spelerpes ruber*). DeKay, J. E. Zoology of New York, pt 3, 1842, p. 80, pl. 17, fig. 43 (*Salamandra rubra*). Dunn, E. R. Some Reptiles and Amphibians from Virginia, North Carolina, Tennessee and Alabama. Proc. Biol. Soc. Wash, 1920*a*, 33:133 (*Pseudotriton ruber ruber*). Holbrook, J. E. North American Herpetology 2d ed. 1842, p. 35, pl. 9 (*Salamandra rubra*).

EURYCEA BISLINEATA BISLINEATA (Green)

(*Salamandra bislineata,* Jour. Acad. Nat. Sci. Phila., 1818 1:352)

Two-lined Salamander, Yellow-backed Salamander

Figures *3e, 4n,* 54–56, 57 *c–e*

The two-lined salamander is an active little species commonly found along the margins of small streams hiding beneath stones and rubbish where the soil is constantly saturated.

Description

Size. This species is among the smallest of our salamanders, rarely 100 mm in total length. Dunn (1926, p. 304) examined 953 specimens of which the largest male measured 115 mm and the largest female 105 mm. Twenty-two adult males from various New York localities average 76.8 mm with extremes of 67 and 92 mm. In these the tail comprises from 46.4 per cent of the total length in the smallest specimens to 50.6 and 53.5 per cent in the larger specimens. In a series of 15 adult females the average length is 76.8 mm with extremes of 61 and 97 mm. In these, the tail comprises from 48.6 to 53 per cent of the total length. Twenty New York specimens of both sexes, not including those mentioned above, average 79.5 mm and vary from 64 to 100 mm.

Form. The body is slender and subcylindrical, with the tail strongly compressed. The head is narrow with the sides nearly parallel back of the eyes and converging in front to the bluntly rounded and swollen snout. The eyes are small, the horizontal diameter not exceeding the distance from the anterior angle of the eye to the end of the snout. Back of the eye there is a vertical fleshy fold in both sexes. The upper lip is swollen in the region of the naso-labial grooves. The commissure of the mouth is slightly sinuous, the angle of the jaws lying just in front of the hind angle of the eye. A fleshy fold from the angle of the mouth is continued backward a short distance. The gular fold is strongly developed and continued on the sides of the neck where it curves upward and forward to meet a horizontal groove running to the eye.

There are 15 costal grooves in the majority of specimens, counting one each in the axilla and groin and three or four intercostal spaces between the appressed toes. In a few there are 16 grooves, one or two imperfectly developed in the groin. The grooves are continued on the upper sides but rarely meet the median impressed dorsal line.

The tail is flattened, elongate oval in cross section, thinner above than below and definitely keeled in many specimens. There are no conspicuous glands and the skin is smooth and shining.

The legs are small, the hind ones larger than the fore but proportionally smaller than in *Desmognathus*. The toes of the hind feet are 1-5-2-4-3; those of the fore feet are 1-4-2-3, the innermost rudimentary in some.

The teeth differ somewhat in the males and females. In the former the vomerine teeth number from seven to ten, and are rather irregularly disposed in arched series between and a short distance behind, the inner nares. The lines are first arched transversely then turn backward and continue a short distance, converging gently and narrowly separated at their extremities. The parasphenoid teeth are in distinct patches well separated their entire length and from the vomerine by about the length of a vomerine series. In the female the vomerine teeth number from seven to 12 in each series. The teeth of the premaxilla and mandible of the male are larger and longer than those of the female and from October to May are monocuspid. The teeth of the female are shorter and bicuspid. (Noble, 1929, p. 2).

The tongue is comparatively small, broadly oval in outline and provided with a stalk which meets the tongue obliquely below.

Color. The general ground color varies from a dull greenish yellow to bright orange-yellow and brown. The ground color is most in evidence on the back in a broad median band and on the lower surfaces where bright yellow predominates. The dorsal light band originates on the head where it is widest just back of the eyes and continues the entire length of the body and the tail to its tip. Within the dorsal light band there is often a median row of small black dots or dashes forming a fairly regular line and on either side of this are small, round scattered black points. Sometimes there is no indication of the median line and the back is flecked with small, black dots continued over the dorsal surface of the head and tail. On each side bordering the median band there is a narrow dorsolateral black band which originates at the eye and extends the length of the trunk and tail. In some individuals the dark bands break up into dashes on the tail and rarely they fade out entirely on the distal third. Below the dark bands the sides are mottled, usually darkest above and fading into the light belly below. The legs and toes are finely mottled above.

The belly is usually bright yellow but is varied with tinges of violet in the region of the heart and red over the liver.

Sexual differences. Differences in the teeth have been noted in a paragraph above. The largest males apparently exceed in size the largest females but the sexes average equal in the series measured. There is very little difference in tail length when individuals of comparable ages are measured. The lower jaw appears to be somewhat more pointed in the male than in the female, when viewed from below, and in some males there is a larger swelling in the region of the naso-labial grooves and the head is wider back of the eyes. The anal lips are papillose in the male and slightly ridged in the female. Noble (1929, p. 1) has pointed out that from October to May and possibly longer, the male may be distinguished from the female by the "glandular area on the chin, and scattering of yellowish or white glands on the lower eyelid, posterior part of the upper eyelid and jaws, as well as on temporal region and neck."

Activities of the Breeding Season

Migration. There are no marked seasonal movements such as characterize the ambystomids but there are minor shifts correlated with the changing seasons. McAtee (1907) found that *Eurycea b. bislineata* in Indiana comes out of the water in November and passes the winter under logs and stones near streams. Noble (1931, p. 419) remarks: "In the New York region the same species is never found on land in midwinter but may be collected in numbers by turning over the stones in the deeper portions of flowing streams." In the region about Albany and Rochester, N. Y., I have collected the adults at all seasons both in water and from beneath stones and logs on springy hillsides where they are found in company with *Desmognathus f. fuscus* and *D. o. ochrophaeus*. When preparing to lay their eggs, the females go into the water and remain for considerable periods.

Mating. Observations on the courtship activities of the two-lined salamander in captivity have been reported by Noble (1929*a*, p. 2) as follows:

From January to April, 1929, many males of *Eurycea bislineata* displayed during the evening a courtship activity in a series of covered crystallizing dishes half filled with water. The period is initiated by an awakening interest of the males in each other and in the females. The males push every salamander in their vicinity with their snouts, but show a continued interest only in the females. The latter are at first passive and allow themselves to be pushed about for short distances. The males nose any part of the female's body and often lift the females up by pushing their snouts under the cloaca or chest. The sexes rub snouts and cheeks, but the most distinctive

pose is a sharp bending of the male's head around the snout of the female, reminding one greatly of the head pose of newts, *Triturus viridescens,* in amplexus.

The second phase of the courtship may begin after an hour of the male's activity but it usually occurs later. The female, which either through her own activity or that of the male, has her snout pressed against his temporal region or his side, slips posteriorly and on reaching his hind limbs straddles his tail with her fore limbs. Her chin is brought close against the base of his tail at a point about a centimeter or more from the legs. This point is immediately posterior to the highest point of his tail. When the female's chin touches his tail, the male steps forward wagging the base of his tail sharply to right and to left. At every bend the female turns her head sharply in the opposite direction. The pair continue their walk about the aquarium, the grotesque wagging of the male's tail contrasting to the ordinary movements of the tail during locomotion in the other salamanders. If other males are prevented from nosing the pair the walk may continue with short interruptions for over an hour. If the female loses her position, she will regain it and continue the straddle walk without a preliminary thrusting of her snout against the body of the male.

How the male *Eurycea bislineata* recognizes the female is not clear from these observations, but it is obvious that differential behavior of the two sexes plays a part in both phases of the courtship. The head, body, and particularly the tail base of the male is a distinct source of attraction for the female. An examination of the integument of these regions in serial sections has revealed a distinctive type of gland. . . .

The hedonic glands are very large on the dorsum of the tail base in *Eurycea bislineata* but they are not visible here in the living animal, nor usually distinguishable on the sides of the body, nor on the legs where they also occur. The whitish glands on the eyelids and in the temporal region of the male, when examined microscopically, are found to be hedonic glands. Sections show that no such glands occur in the female anywhere on the head, body or tail. The mental gland of the male appears to be a mass of hypertrophied hedonic glands although they are slightly translucent, not yellowish white, as the larger hedonic glands on the head are.

Spermatophores. The spermatophores of *Eurycea bislineata* are known from fragments recovered from the cloacal lips of females and from those deposited by captive specimens. Noble and Weber (1929, p. 4) have given an account as follows:

On October 25 (1928) two females were found at Leonia (N. J.) with spermatophores within the cloacal lips. On October 28, two additional females with spermatophores were found in the same place. On November 11, two more females with spermatophores were found in Yonkers, (N. Y.) and on November 25 another female with spermatophore in the cloaca was collected at Englewood, N. J. All seven spermatophores were located in the posterior

half or third of the cloacal orifice and in no case was the outlet of the alimentary tract materially obstructed by the spermatophore. The three spermatophores collected in November were distinctly smaller than the October material but the sperm they contained was found under the microscope to be active. The bulk of each spermatophore was composed of whitish substance and the part which protruded slightly from the cloaca was stained, apparently due to dirt which adhered to the more gelatinous part of the spermatophore. The sperm-cap and the outwardly directed gelatinous material were found under the binocular to be not sharply demarcated one from the other. On December 15 the remnants of a spermatophore were found within the posterior part of the cloaca of a female collected in Yonkers. On January 20, 1929, the remnants of two additional spermatophores were found in two females collected at Closter, N. J. On February 17, 1929, four out of five adult females of *E. bislineata* collected at Leonia, N. J., contained remnants of spermatophores in their cloacas. The above series demonstrates that spermatophores are carried within the posterior part of the cloaca of *E. bislineata* from late October to at least mid-February, and further, that the spermatophores gradually dwindle away.

The complete spermatophore consists of a gelatinous base capped by an elongate head. Noble (1929*a*, p. 3, fig. 4).

The account given above by Noble and Weber would indicate that Koehring (1925, p. 253) was mistaken in assuming that mating is limited to the spring months. She writes,

There have been no spermatozoa found in the spermatheca during the fall and winter months. April may be taken as the average mating season though there must be as variable a season for mating as there is for egg-laying, and many early and late dates have been recorded for Eurycea eggs.

The nests. The two-lined salamander deposits her eggs on the lower surface of a support in running water. I have never found evidence that an excavation is made by the salamander, as is the case in *Necturus* and *Cryptobranchus,* but the situation chosen permits the eggs to be bathed by moving water. The so-called nests may be found in water so shallow that the eggs are barely covered or buried to a depth of eight or ten inches below the surface. In removing a boulder from the bed of a muck-filled stream, a batch of eggs was found attached to the lower surface fully eight inches below the bottom of the stream and a foot below the water surface.

The egg-laying process. Noble and Richards (1930, p. 2) have observed, in the laboratory, the deposition of eggs by females stimulated by pituitary transplants and record the following:

The eggs were attached singly to the underside of the flat stone, the female moving to a new position after each egg was deposited.

In a few cases the animal crawled to the top of the rock for two or three minutes between the laying of each egg. The entire process occupied about one hour. Generally the eggs were attached near the edge of the rock, the tail of the female curling out and up over the edge. The actual laying of each egg required from one to two minutes and was accomplished by the animal pressing the cloaca against the surface of the rock.

Further observations on the egg laying of *E. b. bislineata* were reported by Noble and Richards (1932, p. 1) as follows:

The female clings, upside down, to the under surface of a flat rock. The back and tail are arched so as to bring the cloacal lips in contact with the rock. A place is "felt out" on the stone by the slightly protruding cloaca and the egg deposited. The time between the deposition of each egg depends upon the amount of wandering about the salamander does. In one case the female moved methodically, a few centimeters after depositing each egg. She required on an average, three minutes for the attachment of an egg.

Most of the eggs, which were deposited by stimulated females in November, were found to be fertile, which gives further evidence that the sperm may be carried in the spermathecae during the winter months.

The egg mass. Under natural conditions the eggs are placed fairly close to one another so that the expanded envelops of the majority are in contact. Often there is a compact central lot of eggs with a few scattered more widely around the margin. A linear arrangement is evident in many masses indicating that the female moved ahead a short distance after depositing each egg. The entire complement may cover an area only three inches in its greatest diameter or spread over an area six inches across. Frequently the complements of several females are deposited on the same support and the total found may number in the hundreds. On August 28, 1924, a lot containing 165 eggs was found at Voorheesville, N. Y. Weber (1928, p. 108) records the finding of a cluster of 225 eggs, August 10, 1926, in Essex county, N. Y.

The number of eggs that may be deposited by a single female varies considerably. Noble and Richards (1932, p. 1) found that the average number laid by stimulated females in captivity to be 25, with a maximum of 41. Wilder (1924, p. 77) found the number to vary from 12 to 36 with the average about 18.

My own records of egg masses found under natural conditions in the field, are arranged below in tabular form.

LOCALITY	DATE	NUMBER	STAGE OF DEVELOPMENT
Stamford, N. Y.	June 25, 1922	68	late segmentation and early embryo
Voorheesville, N. Y.	April 20, 1923	43	early embryo
Thacher Park, N. Y.	May 1923	..	unsegmented
Thacher Park, N. Y.	June 11, 1924	26	advanced embryo
Thacher Park, N. Y.	June 23, 1924	..	hatching
McLean, N. Y.	July 16, 1924	..	advanced embryo
Voorheesville, N. Y.	Aug. 28, 1924	165	hatching
Carmel, N. Y.	May 23, 1925	36	early embryo
Voorheesville, N. Y.	Aug. 27, 1925	..	hatching
Rochester, N. Y.	April 11, 1929	18	unsegmented
Ogdensburg, N. Y.	June 3, 1931	..	late embryo
Cold Spring Harbor, N. Y.	June 24, 1932	..	late embryo

From the records given above it is evident that the earliest date on which eggs were found is April 11, 1929. These were unsegmented and the small number may indicate that the entire complement had not been deposited. That they may be deposited at an earlier date is indicated by the record of well-developed embryos found April 20, 1923. Recently deposited eggs have been found as late as June 25th. In May freshly deposited eggs and others at the point of hatching have been found. The latest records for eggs at the point of hatching are August 27, 1925, and August 28, 1924. Eggs at the point of hatching have also been found at Thacher Park, June 23, 1924, and Allegany State Park, August 10, 1926, a period of hatching extending over nine weeks. This is greatly at variance with the findings of Wilder (1924*b*, p. 2) who reported that, in Massachusetts, the period of hatching lies within a range of not more than five weeks.

It is altogether likely that the 68 eggs found June 25th and the 165 eggs found August 28th represent the complements of more than one female. Leaving these groups out of consideration, the average number laid is about 30, a figure which approximates that obtained by Noble from stimulated females.

Verrill (1862, p. 253) was apparently the first to describe the eggs of this species although he recorded them under the name of *Desmognathus fuscus*. On May 20th he found a cluster of 40 attached to the lower surface of a stone.

Sherwood (1895, p. 31) reported eggs found October 25th. This is an exceptionally late date for eggs of this species and raises the question as to their identity. The eggs of *Pseudotriton ruber* resemble those of *E. b. bislineata,* although larger, and are deposited during the late fall and winter months. Wilder (1899, p. 235) reported finding eggs in Massachusetts on May 27th and June 12th, attached as usual to the lower surface of a support in running water.

Dunn (1926, p. 301) indicates May 7, 1921, as an early date for egg laying in the vicinity of Sunderland, Mass.

Larvae retaining a considerable amount of yolk, indicating recent hatching, have been encountered at times but apparently the young scatter rather quickly after leaving the egg envelops and only a few have been found at any one time. A few such young were found at Voorheesville, May 29, 1923, and at Allegany State Park, August 19, 1926.

Females with large eggs ready for laying have been found as follows: Voorheesville, March 13, 1928, April 13, 1926, April 16, 1927, and May 6, 1922. The eggs attain considerable size during the late fall months but, so far as I know, are never laid under natural conditions until the following spring or summer.

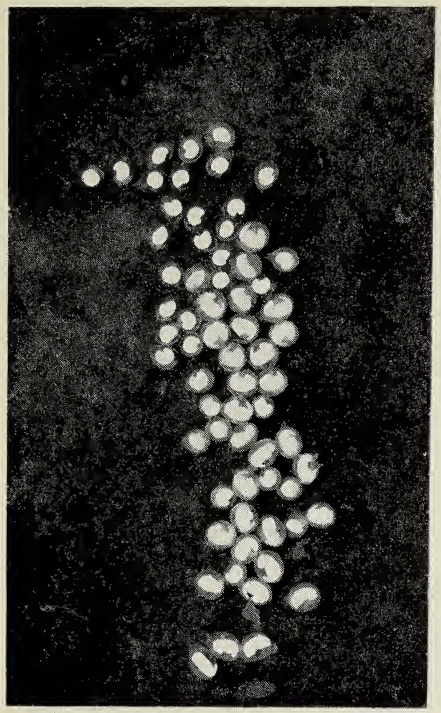
Development

The egg and its envelops. The eggs are unpigmented, varying from white to pale yellow. They are somewhat variable in size in the complement of a single female and are apparently deposited over a considerable period. In captive specimens, Noble and Richards (1930, p. 3) found that the complement might be deposited in about one hour, but under natural conditions the period may well be extended, for eggs are to be found in different stages of development in almost every cluster.

The egg has a diameter of from 2½ to 3 mm and is closely surrounded by the vitelline membrane. There are two definite envelops, the inner having a diameter of 3½ to 4 mm and inclosing a clear jellylike substance, the outer 4½ to 5 mm in diameter and separated from the inner by a thin clear jelly. The outer envelop is thin, tough and elastic and is spread out at the point of attachment to the support, to form a flat, flangelike ring with irregular edges. The measurements given above are for the largest eggs. The outside diameter of the smaller eggs does not exceed 4 mm.

The hatching larvae escape from the egg envelops leaving them attached to the surface of the stone and, in most cases, retaining the original shape. The escape is usually made at the free end but occasionally at the side or base. The hole is small and inconspicuous and closes after the escape of the larva.

Noble and Richards (1932, p. 12, fig. 3*b*) give a somewhat different interpretation of the egg envelops of *E. b. bislineata.* They regard the semifluid jelly within the thin outer envelop as the inner capsule and the layer surrounding the egg as the "fluid space."



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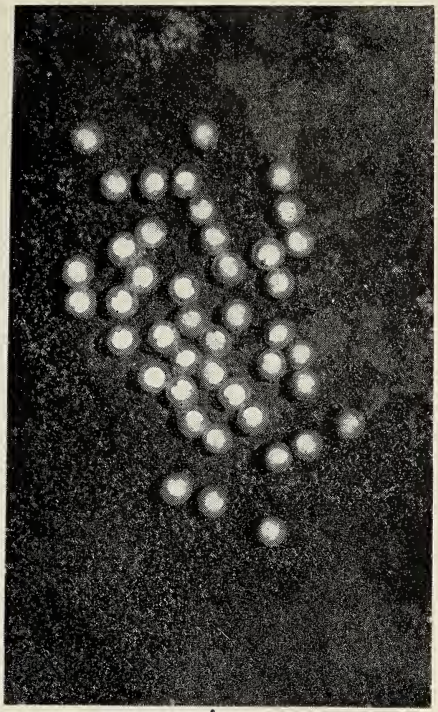

b

c

Fig. 54 a. Egg-cluster of *Eurycea bislineata bislineata*, Stamford, N. Y., June 25, 1922. The large number of eggs, 68, the difference in size and stage of development indicate that two females deposited their eggs on the same stone. b. A typical egg-cluster from Voorheesville, N. Y., Apr. 20, 1923. c. A small section of the egg-cluster shown in " *a* " enlarged. Note the ring-like attachment of eggs (upper left).

The incubation period. I have never been able to follow eggs through the entire period of development in the field. Some embryos which showed differentiation of head, trunk and tail were found April 20, 1923. The majority of them were left in the cold stream in which they were found until June 19th, when the first began to hatch. This is a period of 60 days to which should be added an additional week or ten days to account for development up to the time of discovery. It is altogether likely that eggs deposited later in the season, or in warmer waters, hatch in a much shorter period. Those kept at room temperature of about 68° to 70° F. began to hatch May 29th. Since recently hatched young have been found May 29th, and advanced embryos as early as June 3d, in New York State, it is evident that some may be deposited in March. There is some indication of pigment before hatching.

The newly hatched larvae. The newly hatched larva is exceedingly slender when viewed from above and proportionally deep sided. Of six specimens measured two were 12 mm long and four 12.5 mm. The gray or slightly brownish pigment is disposed in a netlike pattern on a light yellowish or slightly greenish yellow ground. The yellowish ground color is mostly confined to the trunk, fading out on the head so that the area in front of the eyes is mostly grayish white and stopping abruptly at the base of the tail. There is a broad middorsal light band with irregular edges within which the pigment is disposed in small flecks. At the back of the head the band splits and sends a branch to each eye. Over the rest of the head the pigment forms a reticulated pattern. On each side of the light dorsal band, the pigment is concentrated to form a dorso-lateral band which incloses a series of six to nine (usually seven) definite light spots. The sides below the lateral bands are more or less regularly mottled. The venter is yellow, colored by the yolk, free from pigment and sharply marked from the darker sides. The ventral tail fin is usually semitransparent and free from pigment. It continues the line of the belly and is almost straight but the dorsal fin is widened abruptly above the insertion of the hind legs. Viewed from the side, the tail is broad and very bluntly rounded at the tip, pigmented except on the ventral fin and marked by thin vertical lines that indicate the position of the vertebral segments. The costal grooves are inconspicuous. The gills bear few filaments and are only lightly pigmented. The fore legs have the toes indicated but the hind legs are represented only by elongated buds. The eyes are black but apparently not completely functional.

In some there is a tinge of gold in the iris and a broad dark bar through the eye from gills to snout.

Length of the larval period. The detailed studies of H. H. Wilder (1899) and I. W. Wilder (1924*a*, p. 8) have shown that the larval life, "continues through the summer subsequent to the year of hatching and that there is a laggard group present still a year later in smaller or larger numbers." The so-called larvae include, "individuals of ages ranging from a year or younger to two and three years and in stages of development ranging from the typical larval through the greatly prolonged premetamorphic and metamorphic to transforming individuals" (Wilder, 1924*a*, p. 5).

Mature larvae. Larvae reach the premetamorphic condition at various ages and lengths. The largest I have measured which still retained the gills fully developed were 65 mm long. Dunn (1926, p. 299) measured larvae which had attained a length of 68 mm.

The fully developed larva is characterized by the broad, depressed head and the deeply keeled tail. The dorsal tail keel originates above and slightly behind the insertion of the hind legs, very gradually widens to about the middle of its length and then as gently tapers to the rounded tip. On the lower side, the tail fin originates at the vent and widens evenly and gently to the end.

In many full-grown larvae, the early larval pattern is retained with little modification. The dorso-lateral light spots become somewhat obscured but are evident in fairly well defined rows on either side of the median dorsal light band. In some individuals, the dark pigment which surrounds the dorso-lateral light spots in younger larvae, breaks up and leaves only a broad median light band with irregular edges. The dorsal keel of the tail is frequently lighter along the free margin and mottled on the sides. Along each side of the keel at its juncture with the tail proper, the pigment is more densely aggregated to form a rather conspicuous band within which there is frequently a fairly definite series of small, round, light spots continuous with those of the trunk. The ventral tail keel is largely free from pigment at the base of the tail but is lightly mottled distally.

The sides of the head are blotched and mottled with gray, the gills short with the filaments thin, deep and pigmented. The sides of the trunk are mottled, darkest above and fading to the pale venter at the line of the legs. In some individuals there is a strong indication of a secondary row of pale spots on the sides above the upper level of the legs and a faintly defined row at the level of the legs.

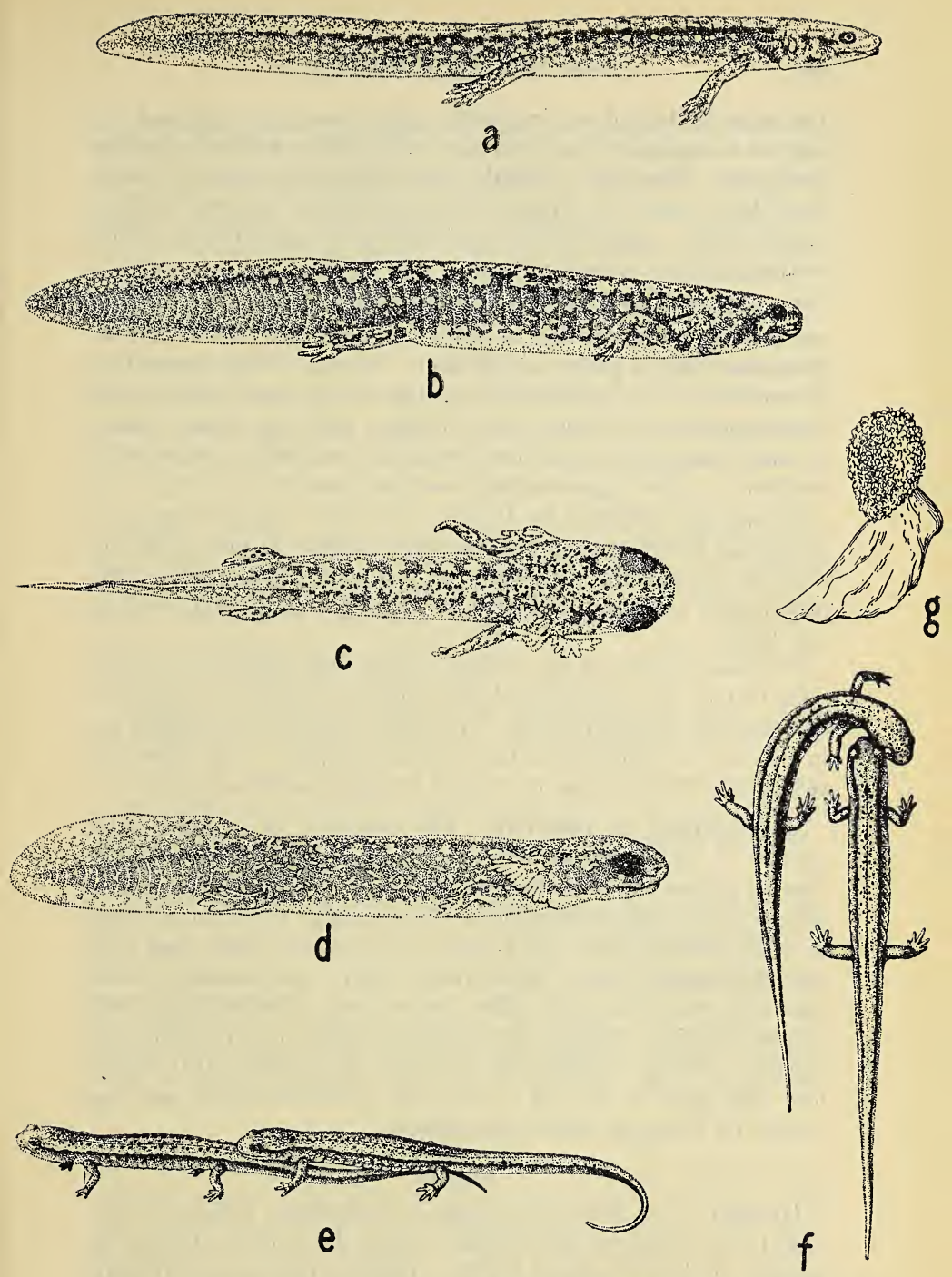

Fig. 55 *Eurycea bislineata bislineata*. a. Full-grown larva, approaching transformation, Voorheesville, N. Y., Mar. 13, 1929. Actual length, 62 mm. b. Larva from Rainbow brook, St Lawrence Co., N. Y., Aug. 16, 1933. In streams with dark bottoms, the larvae become very highly pigmented. Actual length, 61 mm. c. Larva at hatching, Thacher Park, N. Y., June 11, 1924. Actual length, 13 mm. d. Same, side view. e. Courtship, male left; female, right (after Noble). f. Courtship, male left; female right (after Noble). g. Spermatophore (after Noble). H. E. R., del.

The sides of the tail are frequently darker than the trunk and the pigment is segregated to form faint vertical bars with pale, linelike interspaces. The legs are mottled above and pale beneath. Larvae from dark waters, or from streams with dark bottoms tend to become highly pigmented and the light spots stand out in strong contrast against the dark ground.

Transformation. Wilder (1924*a*, p. 2) noted individuals approaching transformation as early as April 14th and as late as November 28th, a period of 228 days. In fact, Wilder found that in one case "two individuals hatching at the same time in the laboratory from the same batch of eggs, and kept always under the same temperature and food conditions, reached a metamorphic condition at dates approximately one year apart."

It was also indicated by Wilder (*ibid.*) that the size range of individuals in the metamorphic condition is from 43 mm to 76 mm with the average for both sexes of 52.5 mm. The smallest fully transformed individual measured by Dunn (1926, p. 299) was 47 mm long.

The color pattern of the recently transformed individual is essentially that of the adult although the degree of intensity of pigmentation may be considerably less. The most conspicuous changes are in the loss or reduction of the light larval spots of the sides, the reduction of the tail fins, the loss of the gills and labial folds.

Development to maturity. The dissection of a considerable number of individuals of both sexes indicate that sexual maturity may be attained by some females when only 61 mm in total length, and by males when 67 mm long. These lengths are often exceeded by fully developed larvae and premetamorphic individuals and indicate that maturity may be attained within a comparatively short time after transformation. Since the majority of individuals of this species transform during July (Wilder, 1924*a*, p. 5), continuing, however, through summer and early fall, it is evident that mating may take place in the fall of the year of transformation and egg laying the following spring and summer.

Habits

General. The adults are usually in concealment during the daylight hours and are to be found by turning the stones or logs at the margins or in the beds of brooks. Ditmars (1905, p. 173) characterizes this species as follows:

The two-lined salamander is an extremely active species. It is usually found hiding under flat stones in the beds of brooks not

actually under water, but where the soil is thoroughly saturated with moisture. When disturbed in its hiding places, it does not entirely depend on its diminutive limbs for escaping from danger, but makes surprisingly rapid progress by doubling its body into a series of lateral undulations and suddenly straightening it. The result is a number of bewildering jumps. This performance is varied with a snakelike wiggling. Thus with a combination of agile motions, the little animal makes like a flash for the water and secretes itself among the stones.

The two-lined salamander is perfectly at home in the water where it assumes the habits of a larva. The body at rest is held nearly straight with the limbs extended at the sides. It swims rapidly with lateral undulations of the body or crawls about on the bottom, the diagonally opposite legs moving together.

Food. Surface (1913, p. 100) examined a considerable number of specimens of the two-lined salamander and recorded the following food items: "spiders, mites, thousandlegged 'worms,' undetermined insects, Hemiptera, Homoptera, flies, beetles and their larvae, Rove Beetles or Staphylinidae, Chalcis flies, and an undetermined salamander." Smallwood (1928, p. 94) remarks:

Eurycea bislineata eat insect larvae, earthworms and adult insects; while the young larvae eat caddis-fly larvae and beetle larvae.

The most recent account of the food is that by Hamilton (1932, p. 86) who examined the stomach contents of 47 specimens and employed the percentage-by-bulk method in determining the relative amounts of the various food items.

Beetles and their larvae, 16.2; spiders, 14; sowbugs, 13.7; mayflies, 10.5; diptera, 10; annelids, 9.8; stonefly nymphs, 5.4; thrips, 5; and undetermined insects, 9 per cent; also a trace of midge larvae, hymenopterous insects and sand. Many of the salamanders were taken from streams, some wholly submerged in fast water. These were feeding upon the minute nymphs of stoneflies and mayflies, with an occasional midge larva. Several examined in January had eaten well, in spite of freezing temperatures and much ice in the streams.

Habitat

While essentially an animal of the brooksides, the two-lined salamander is also to be found in and about springs, in boggy places and occasionally in fairly dry situations some distance from water. Morse (1904, p. 113) writes: "It is found always near running water, although seldom seen in it, but preferring to remain within ready access. A rock or stick partially placed in the water is a favorite place for concealment." Allen (1899, p. 75) comments on the

preference shown for small streams, "This slender little salamander is rather common under pieces of wood by the wet banks of little forest brooks, in much the same localities that *Desmognathus fuscus* inhabits. It is agile, and when once aroused, scrambles about with great rapidity. I found one in the crannies of a big log, lying across a small brook. On trying to capture it, it scrambled off the log, and, plunging into the water, swam quickly to the bottom and hid beneath a leaf."

Verrill (1862, p. 253) writes of it in Maine: "Occurs in cold, rapid, rocky brooks and springs or under stones close to their margins."

Reed and Wright (1909, p. 403) speak of it as common in the Ithaca region, "in and about cold swift brooks." Sherwood (1895, p. 31) reported it in the vicinity of New York city, as "very common under flat stones in or near shallow brooks."

While collecting at Turkey hill near Ithaca, N. Y., August 8, 1923, an adult was found under a dry board some distance from the stream; other adults were found in the near-by stream itself.

At Lake Eaton, N. Y., larvae were fairly common among the stones along the shore where they must have been subjected to considerable wave action, if they remained inshore during storms.

In New York State the two-lined salamander is frequently associated with *Desmognathus f. fuscus, D. o. ochrophaeus, Gyrinophilus p. porphyriticus, Pseudotriton r. ruber* and *Eurycea longicauda. D. f. fuscus* is sometimes found in situations that do not appear suitable for the two-lined salamander, as at Bushnell Basin, N. Y., where in a shallow, sand-bottomed, spring-fed stream *D. f. fuscus* is very abundant and the two-lined salamander very rare or absent. *Eurycea b. bislineata* is sometimes eaten by *Gyrinophilus p. porphyriticus.* Wright and Haber (1922, p. 31) writing of the carnivorous habits of the purple salamander, include the two-lined salamander among the species taken. On one occasion, while collecting salamanders near Voorheesville, N. Y., a number of purple salamanders were confined in a cloth bag for transportation and en route to Albany, disgorged several partly digested specimens of *E. b. bislineata.*

Remarks

Apparently the earliest record for the species in New York State is that of Eights (1835) who collected some specimens at Albany September 11, 1835. As indicated in an earlier paragraph, the eggs were first reported by Verrill (1862) who recorded them under the name of *Desmognathus f. fuscus.* One of the earliest

accounts of the life history is that by Wilder (1899). Mating habits and spermatophores were described by Noble (1929). Goodale (1911) studied the early development of the species.

To me there seems to be a closer relationship between *Eurycea b. bislineata* and *Eurycea b. wilderae* than to the somewhat more specialized *E. b. cirrigera.*

Range

"Quebec, New Brunswick, to Indiana, Tennessee, and Virginia." (Stejneger and Barbour, 1933, p. 18.)

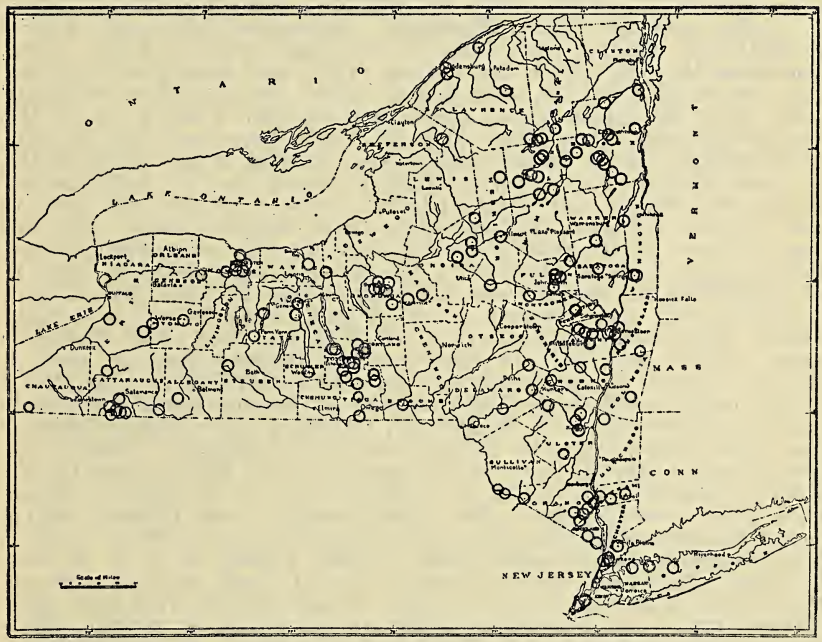

Fig. 56 New York localities for *Eurycea bislineata bislineata.*

Distribution in New York

Throughout the State in suitable situations from the higher mountainous regions to Long Island and Staten Island.

Specific records. ALBANY: Sept. 11, 1835 (Eights, 1835); Albany June 4, 1892, 1 ad., N. Y. S. M. No. 1 (S. S. Smith); sev. 1891–92, (46th Ann. Rep't N. Y. State Mus., 1893); (62d Ann. Rep't N. Y. S. Mus. 1909); June 6, 1902, 1 larva, N. Y. S. M. No. 50 (F. C. Paulmier); (Bishop, 1923); *Clarksville,* May 8, 1926, 1 spec. (S. C. B. and B. S. Bronson); *Dripping Well* (Eights, 1835; Allen, 1868); *Karners,* Amoena brook, May 25, 1902, N. Y. S. M. No. 47 (F. C. Paulmier); June 14, 1902, 2 ads., N. Y. S. M. No. 53, (F. C. Paulmier); July 10, 1902, 4 larvae, N. Y. S. M. No. 63 (F. C. Paulmier); *Meadowdale,* Apr. 16, 1927, 1 ad.

(K. F. Chamberlain); *Potter hollow,* June 24, 1936 (Hall and Stone); *Thacher Park,* May 1923, eggs (J. Cook); June 11–23, 1924, eggs; Feeney pond, May 8, 1928, 1 larva; Indian Ladder, June 27, 1921, 1 larva, 1 ad., N. Y. S. M. No. 9121 (W. J. S.); July 19, 1922, 2 ads., N. Y. S. M. No. 1207; *Minelot creek,* June 21, 1927, 9 larvae (D. Cook); *Thompson's lake,* June 20, 1908, 3 ads., N. Y. S. M. No. 98 (F. H. Ward); *Voorheesville,* May 6, 1922, 1 ad. ♀, N. Y. S. M. No. 9180; May 29, 1923, 1 larva; Mar. 1, 1924, 1 ad., N. Y. S. M. No. 1451 (S. C. B. and W. J. S.); Apr. 5, 1924, many seen, 3 ads., (S. C. B. and W. J. S.); Aug. 28, 1924, larvae; Nov. 12, 1924, 2 ads., 1 larva (S. C. B. and W. J. S.); May 18, 1925, 1 spec.; Aug. 27, 1925, eggs and larvae; Sept. 25, 1925, 1 larva (S. C. B. and W. J. S.); Apr. 13, 1926, several spec., (S. C. B., W. J. S. and H. H. Cleaves); Apr. 29, 1926, 6 spec. (S. C. B. and B. S. Bronson); Dec. 9, 1926, 1 spec. (S. C. B. and W. J. S.); Apr. 16, 1927, 3 ads., U. R. No. 3273 (S. C. B. and B. S. Bronson); Apr. 30, 1927; July 29, 1927, several (S. C. B. and T. I. Storer); Nov. 11, 1927, few; Mar. 13, 1928, 1 ad. ♀, 1 larva (S. C. B. and W. J. S.). ALLEGANY: *Friendship,* May 28, 1933, U. R. No. 3010 (M. Hall). BROOME: *Binghamton* (G. Bump). CATTARAUGUS: *Allegany State Park,* Oct. 20, 1934, 1 spec., U. R. No. 3443; Blacksnake Mt., July 1931, 1 larva; Aug. 1931, 1 ad.; Breed's run, Oct. 22, 1932, several ads.; Oct. 28, 1933, 5 spec., U. R. No. 3199; Oct. 20, 1934, 1 ad., U. R. No. 3443; Buffalo camp, Aug. 22, 1926, 1 ad., N. Y. S. M. No. 3208 (Bishop, 1927); Sept. 21, 1931, 1 ad.; Coon run, Aug. 3, 1922, 1 ad., (Bishop, 1927); Mount Seneca, Aug. 17, 1926, 1 ad., N. Y. S. M. No. 3180 (Bishop, 1927); Natural History School, Oct. 15, 1938, larvae; Quaker run, July 6, 1921, 1 ad., (Bishop, 1927); *Otto,* Feb. 20, 1931, 1 spec. (N. M. Fuller); *Playfords spring area,* Pleasant Valley, Feb. 20, 1931, 1 larva (N. M. Fuller). CAYUGA: *Duck Lake area* (Wright and Moesel, 1919). CHAUTAUQUA: 2 mi. N. of *Clymer,* Sept. 12, 1937, 1 ad. COLUMBIA: *Copake,* June 12, 1936, 2 ads. DELAWARE: 2 mi. E. of Downsville, July 1, 1935, 9 spec. U. R. 3868; Fish's Eddy, July 8, 1935, 2 larvae; *Halcottsville,* 1913, 1 larva, A. M. N. H. No. 16875 (A. H. Helme); 9 spec., Brook. Mus. No. 978 (Dunn, 1926); *Stamford,* June 25, 1922, 2 ads., N. Y. S. M. No. 9247; July 4, 1935, 1 ad. DUTCHESS: *Red Hook,* July 5, 1938 (Van Auken). ERIE: *Hamburg,* Hampton brook, spring and summer 1925, several (R. R. Humphrey); *Holland,* 3 Valley Nature Reserve, Aug. 1–16, 1930, 7 spec., U. R. No. 2118 (E. L. Hilfiker). ESSEX: 10 spec. (Yarrow, 1882; Cope, 1889); 18 spec., U. S. N. M. No. 3740 (S. F. Baird); 2 spec., U. S. N. M. No. 16691–92 (C. F. Batchelder); *Artist brook,* July 20, 1925, 3 spec.; *Blue Ridge,* June–Sept. 1926 (Weber, 1928); *Boreas mountain, Elk cove, Clear pond,* June–Sept. 1926 (Weber, 1928); *Lake Champlain,* Camp Douglas, Aug. 19, 1902, 1 larva, N. Y. S. M. No. 58 (F. C. Paulmier); *McIntyre brook,* Aug. 23, 1928, few spec.; *Mount Marcy,* Sept. 3, 1922, 1 ad., N. Y. S. M.; *Mount Pharaoh,* June–Sept. 1926 (Weber, 1928); *Newcomb,* Oct. 5, 1917, 1 ad., N. Y. S. M. No. 3782; *Paradox lake,* Severance, June–Sept. 1926, eggs, Aug. 10, 1926 (Weber, 1928); *St Huberts,* Sept. 1, 1921, 2 ads., A. M. N. H. No. 14,544–5 (C. H. Rogers); Upper Hudson R. between *Tahawus* and *Lake Sanford,* June–Sept. 1926 (Weber, 1928); near *Wilmington,* Summer 1931 (Burt, 1932); *Westport* (7th Ann. Rep't State Cab. Nat. Hist., 1854); 6 spec., U. S. N. M. No. 3745, 3915 (S. F. Baird); 6 spec. (Yarrow, 1882; Cope, 1889). FRANKLIN: near *Axton,* May 7, 1903 (H. E. Kinne); (Evermann, 1918); outlet of *Lake Madeleine,* July 24, 1933, 1 juv.; Cold brook near *Tupper Lake,* Aug. 18, 1933, 4 spec., U. R. No. 3203 (J. R. Greeley). FULTON: *Bleeker,* July 23, 1932, 1 ad.; *Gloversville,* Sept. 1906, 4 spec., N. Y. S. M. No. 86, 436 (C. P. Alexander); Sept. 26, 1908, 2 ad., N. Y. S. M. No. 95,647 (C. P. Alexander); *Mayfield creek,* July 24, 1932, 1 larva (G. P. Cooper); *Sacandaga Park,* June 6, 1908, 2 spec., N. Y. S. M. No. 94 (C. P. Alexander). GENESEE: *Bergen swamp,* Aug. 5, 1916 (Wright and Moesel, 1919); Aug. 18, 1918 (Wright and Moesel, 1919); June 8, 1929, larvae; June 17, 1929, U. R. No. 1123; Apr. 17, 1937, ads. (M. Wright). GREENE: *Coxsackie,* 1851 (5th Ann. Rep't State Cab. Nat. Hist., 1852); (Cope, 1889); 17 spec.,

U. S. N. M. No. 3737 (S. F. Baird); *East Durham,* June 24, 1936 (Hall and Stone); near *Schoharie creek,* Aug. 4–Sept. 14, 1896 (Mearns, 1898). HAMILTON: *Clear (Eaton) pond,* June 19, 1933, 1 spec., U. R. No. 3208; Aug. 18, 1933, 39 spec., U. R. No. 3202 (J. R. Greeley); *Eighth lake,* Aug. 1925 (R. R. Humphrey); *Indian lake,* Snowy Mountain, Sept. 4, 1927, N. Y. S. M. No. 4045 (J. Heller); near *Long Lake,* summer 1931 (Burt, 1932); *Raquette drainage,* Pine Br., Sept. 1, 1933, 2 spec., U. R. No. 3272 (J. R. Greeley); near *Raquette lake,* summer 1931 (Burt, 1932); *Wakely pond,* Aug. 29, 1932, 1 larva, U. R. No. 3205. HERKIMER: *Mohawk,* 1895, C. M. No. 1667–72 (Ruedemann); *Twitchell creek,* Aug. 17, 1931, larvae; *Wilmurt,* Aug. 1, 1903, 1 ad., N. Y. S. M. (F. C. Paulmier). LEWIS: *Indian river,* Aug. 7, 1931, larvae. MADISON: *Cazenovia,* Aug. 1908, 3 ad., N. Y. S. M. (H. Vrooman); (Fowler and Dunn, 1917; Dunn, 1926); *Peterboro,* July 16, 1900, 3 spec., U. S. N. M. No. 28299–301 (G. S. Miller). MONROE: *Rochester,* Allen's creek, Apr. 11, 1929, ads. and eggs (S. C. B. and R. Hart); Durand-Eastman park, (Wright and Moesel, 1919); Genesee Valley park, May 18, 1916 (Wright and Moesel, 1919); *Scottsville,* Cedar swamp, Apr. 15, 1930 (B. Segal); Nov. 12, 1930, U. R. No. 1331 (P. R. Needham); *Tufa glen,* June 29, 1929, U. R. No. 860 (S. C. B. and R. Hart); Oct. 22, 1930, U. R. No. 1222; Nov. 16, 1931, several, U. R. No. 2081; Jan. 30, 1933, several ads. (J. Westman); Mar. 12, 1933, 2 ads., U. R. No. 3129 (S. C. B. and H. Chrisp); Oct. 1, 1933, 2 spec., U. R. No. 3201; Nov. 6, 1936, sev.; Feb. 28, 1937, sev. MONTGOMERY: *Nelliston,* Nov. 18, 1922, 1 ad., N. Y. S. M. No. 9434. NASSAU: *Glen Head,* 1915, 1 yg., A. M. N. H. No. 3744 (I. M. Ketcham); *Glen Cove,* July 11, 1938, 8 spec., U. R. No. 4453; *Sea Cliff,* Aug. 8, 1938, sev. U. R. No. 4452. ONEIDA: 42 spec., Roy, Ont. Mus. No. 484–507 (Dunn, 1926); *Barneveld,* May 27, 1916, 1 ad., (F. Harper); Moulton brook near *Floyd,* May 4, 1916 (F. Harper); *Purgatory creek,* Aug. 13, 1931, 3 larvae, U. R. No. 2046; *Remsen,* May 31, 1916 (F. Harper). ONONDAGA: *Butternut creek,* July 8, 1927, larva, R. Sta. No. 4240 (W. A. Dence); July 12, 1927, larva, R. Sta. No. 4242 (W. A. Dence); *Jamesville* (Britcher, 1903); *Onondaga valley* (Britcher, 1903); Hopper's glen (J. R. Slater); *Pompey Hill* (Britcher, 1903); *Syracuse,* Dec. 9, 1914, 1 ad. R. Sta. No. 8 (Paddock); *West Onondaga creek,* July 5, 1927, R. Sta. No. 4237 (W. A. Dence); *White lake,* June 21, 1927, R. Sta. No. 4231 (W. A. Dence). ONTARIO: *Canandaigua lake,* Menteith glen, Sept. 22, 1928, 4 spec., (E. A. Maynard); *Geneva,* common; *Kashond creek,* May 20, 1932, Hobart College (T. T. Odell); *Naples,* Aug. 21, 1923, 1 ad. ORANGE: 1 mi. S. of *Harriman,* Apr. 12, 1930 (Burt, 1931); *Highland Falls,* 9 spec., U. S. N. M. No. 23213-21 (E. A. Mearns); *Mountainville,* June 12, 1920, 1 ad., A. M. N. H.; *Palisades Interstate Park,* Bear Mt. Section, summer 1923, 2 ads., 4 yg., A. M. N. H. No. 24,179-82 (G. S. Myers); Car pond, Aug. 26, 1918, 1 ad., R. Sta. No. 2172 (C. C. A. and Hankinson); Kanohwahke lakes, July–Aug. 1923, common (Myers, 1930); Little Long pond, Aug. 23, 1918, 1 larva, R. Sta. No. 2156 (C. C. A. and Hankinson); *Port Jervis* (G. Bump). PUTNAM: *Carmel,* May 23, 1925, eggs (S. C. B., H. Hasbrouck and H. Cleaves); *Garrison,* 1 spec., A. M. N. H. No. 2243 (Dunn, 1926); (Cope, 1889); *McKeel Corners,* July 16, 1936, 1 larva. U. R. No. 4078; *Tompkins Corners,* July 5, 1922, 1 ad. (A. Wolf). RENSSELAER: *Defreestville,* Oct. 22, 1920, larvae, N. Y. S. M. (W. J. S.); *East Nassau,* June 22, 1922, N. Y. S. M. (S. C. B. and A. Wolf); Aug. 22, 1927 (S. C. B. and W. J. S.); *Mill creek,* Oct. 24, 1920, 9 larvae and 1 ad. (W. J. S.); *Johnsville,* July 8, 1936, sev.; *Schodack,* Apr. 22, 1922, 1 ad. 1 larva, N. Y. S. M. No. 9152. RICHMOND: *Richmond,* Ketchum's mill pond brook, 1931 (Wilmott, 1933); *Staten Island* (Davis, 1884); Apr. 4, 1909, 2 ads., A. M. N. H. No. 2505–6 (B. H. Brook). ROCKLAND: *Monsey,* 11 spec., A. M. N. H. No. 3658–63, 3677–81 (Dunn, 1926); *Orangeburg,* June 7, 1923, ads., A. M. N. H. No. 18,793, 18,798 (G. K. Noble and G. S. Myers). ST LAWRENCE: *Madrid,* 5 spec., U. S. N. M. No. 3736 (Cope, 1889); *Ogdensburg,* June 3, 1931, 3 spec., U. R. No. 2039; *Rainbow brook,* Aug. 16, 1933, 18 spec., U. R. No. 3204 (J. R. Greeley); *Tibbett's creek,* June 3,

1931, 2 ads., 2 larvae, eggs; *Tupper lake,* Aug. 14, 1933, 10 larvae, U. R. No. 3207. SARATOGA: *Hudson dr.,* Wolf creek, Aug. 10, 1932, 1 larva, U. R. No. 3206; *Porter Corners,* July 1932, 4 larvae. SCHENECTADY: near *Mariaville,* May 5, 1923. SCHUYLER: *Aunt Sarah's falls,* Sept. 20, 1932, 1 ad. (J. A. Weber). STEUBEN: *Arkport,* May 14, 1933, 1 spec., U. R. No. 3200 (F. L. Coots). SUFFOLK: *Cold Spring Harbor,* July 8, 1902, 8 larvae, N. Y. S. M. No. 59 (F. C. Paulmier); July 10, 1902, larva, N. Y. S. M. No. 57 (S. R. Williams); 1914, 2 spec., U. S. N. M. No. 52213–14 (A. M. Banta); many larvae, July 2–4, Aug. 7–15, 1919 (Wilder, 1924, p. 7); June 24, 1930 (P. R. Needham); July 26, 1930 (P. R. Needham); *Smithtown,* 5 spec., Field Mus. (Dunn, 1926). SULLIVAN: *Fish Cabin creek,* June 20, 1935, 1 larva; *Smith's Switch,* June 27, 1935, 2 ads. U. R. No. 3870. TIOGA: *Berkshire* (Dunn, 1918, 1926); M. C. Z. No. 232 (S. Torrney); M. C. Z. No. 236, larvae, 238, 1116 (A. Mayor); M. C. Z. No. 1114 (Dr Hough); M. C. Z. No. 1909, 7 spec.; M. C. Z. No. 4571–76, larvae (T. S. Cary); *Candor,* Aug. 26, 1935, 2 ads.; *Nichols* (Cope, 1889); *Richford,* Oct. 11, 1924, 1 spec. (F. Harper); *Willseyville,* Oct. 17, 1923, 1 ad. (F. Harper). TOMPKINS: *Cayuga lake,* west end, Jan. 9, 1916, C. U. *Freeville,* May 16, 1911, eggs, C. U.; *Groton,* July 7, 1918, 1 spec. (J. W. Corrington); Apr. 5, 1920, C. U.; *Ithaca,* 1904, M. C. Z. No. 3148 (R. V. Chamberlin); U. Mich. No. 32432, 36028, 42466 (Dunn, 1926); C. U. No. 6560 (Dunn, 1926); Apr. 13, 1909, 2 spec., U. S. N. M. No. 39407–08 (A. A. Allen); Apr. 9, 1922, 1 spec. (H. C. Huckett); 1927, C. M. No. 4494 a, b (Katheryn Power); Beebe lake, Apr. 27, 1925, 1 spec. (F. Harper); Bool's backwater, May 20, 1910, C. U.; Mar. 14, 1912, C. U.; Feb. 6, 1915, C. U.; Feb. 14, 1917, C. U.; Cascadilla creek, Mar. 12, 1913, C. U.; Cascadilla valley, Sept. 3, 1919, 2 spec. (J. W. Corrington); Cascadilla woods, Oct. 1, 1924, 2 spec., (F. Harper); East Bools, May 2, 1911, C. U.; Fall creek, Apr. 20, 1914, C. U.; Apr. 21, 1924, 1 spec. (F. Harper); Forest Home, Jan. 21, 1924 (M. E. VanDeman); Glenside, Apr. 5, 1920, C. U.; *Larch meadows,* Apr. 24, 1923, C. U.; *McLean bogs,* May 27, 1919, 1 ad., 4 larvae, N. Y. S. M. No. 8596, 8597, 8600, 8603, 8604 (S. C. B. and A. H. Wright); 1922–1925 (Leffingwell, 1926); 3, N. Y. S. M. No. 903; Oct. 14, 1922, several spec. (F. Harper); July 16, 1924; May 3, 1925, 1 spec. (F. Harper); May 2, 1934, 1 ad., U. R. No. 3411; *Mud pond,* McLean bogs, July 1, 1916, C. U. (A. H. Wright); *Michigan hollow,* Jan. 2, 1911, larvae, C. U.; *Mount Pleasant,* Apr. 9, 1922, C. U.; *Taughannock falls,* June 11, 1919, 2 spec. (J. W. Corrington); *Taughannock gorge,* Oct. 1, 1922, C. U. (R. R. H.); *Turkey hill,* Aug. 8, 1923 (S. C. B. and A. H. W.). ULSTER: *Ashokan,* Aug. 3, 1909, yg., 1 ad., A. M. N. H. No. 2150, 2153 (A. L. Treadwell); Aug. 9, 1909, 2 spec., A. M. N. H. No. 2156 (A. L. Treadwell); Aug. 14, 1909, yg., A. M. N. H. No. 2160 (A. L. Treadwell); *Big Indian valley,* Sept. 1918, 1 spec. (W. T. D.); 6 spec., Brook. Mus. No. 1260 (Dunn, 1926); *Esopus creek,* Catskill Mountains, 1880–1882 (Bicknell, 1882); *Minnewaska,* July 2, 1936 (Hall & Stone); *Dwaar kill,* July 2, 1936, U. R. No. 4080; *Woodstock,* 1018, 5 spec., U. S. N. M. No. 3915, 61121, 61127–9 (E. Uhlenhuth). WARREN: *Lake George,* Elizabeth island, July 24, 1920, 1 ad., N. Y. S. M. WASHINGTON: *Greenwich,* June 18, 1932, 1 larva; *Hartshorn creek,* June 24, 1932, 8 spec. (G. P. Cooper); June 26, 1932, 5 larvae (G. P. Cooper). WAYNE: *North Rose,* July 30, 1909, 4 spec., U. S. N. M. No. 39082–5 (A. C. Weed). WESTCHESTER: *Grassy Sprain reservoir,* 1930 (Burt, 1931); *Nepperhan,* Jan. 8, 1928, 1 ad., 5 larvae (P. Schiffer); *White Plains* (Deckert, 1914); *Yonkers,* Apr. 20, 1919, 1 ad., A. M. N. H. No. 6394 (G. K. Noble and K. P. Schmidt); Oct. and Nov. 1928 (Noble and Weber, 1929); Dec. 15, 1928, Feb. 17, 1929 (Noble and Weber, 1929). WYOMING: *Strykersville,* Oct. 7, 1928, 1 spec. (F. J. Holl); *Warsaw,* June 6, 1937, 4 larvae, (Van Auken).

Records too indefinite to be placed under counties. From New York and Pennsylvania to Ohio (DeKay, 1842); from Maine to Wisconsin to Florida and Louisiana (Cope, 1869); occurs all over the state (Eckel and Paulmier, 1902); general and very abundant (Ditmars, 1905); *Catskills* (Fowler and Dunn, 1917); 4 spec., U. S. N. M. No. 23177–80 (E. A.

Mearns); 9 spec., U. S. N. M. No. 23200–23202–9 (E. A. Mearns) A. N. S., sev.; near *Cayuga lake,* 1925–1932 (Hamilton, 1932); common in region of *Hudson Highlands* (Mearns, 1898); *Long Island,* Oct. 10, 1881, many spec. A. M. N. H. No. 2121 (N. Pike); 1884, many spec., A. M. N. H. No. 2083, 2086, 3744–5 (N. Pike); *Northern New York,* (Baird, 1850).

Condensed Bibliography

Life history and habits. Bishop, 1927, p. 55–56 (*Eurycea b. bislineata*); Ditmars, 1905, p. 173–74 (*Spelerpes bilineatus*); Dunn, 1924, p. 299–303 (*Eurycea b. bislineata*); Hamilton, 1932, p. 86; Smallwood, 1928, p. 94 (*Eurycea bislineata*); McAtee, 1907, p. 15 (*Spelerpes bislineatus*); Noble, 1929*a*, p. 1–5 (*Eurycea bislineata*); Noble and Richards, 1930, p. 2; Noble and Richards, 1932, p. 2 (*Eurycea b. bislineata*); Noble and Weber, 1929, p. 5 (*Eurycea bislineata*); Surface, 1913, p. 100 (*Spelerpes bislineatus*); Verrill, 1862, p. 253 (*Desmognathus fuscus*); Wilder, 1924, p. 77–80 (*Eurycea bislineata*); Wilder, 1924*a*, p. 1–112; Wilder, H. H. 1899, p. 231–46 (*Spelerpes bilineatus*); Wright and Haber, 1922, p. 32 (*Eurycea bislineata*).

Distribution in New York. Baird, 1850, p. 287 (*Spelerpes bilineata*); Baird, 1852, p. 21; Bicknell, 1882, p. 124, 125 (*Spelerpes bilineatus*); Bishop, 1923, p. 67 (*Eurycea b. bislineata*); Bishop, 1927, p. 55–56; Britcher, 1903, p. 120 (*Spelerpes bilineatus*); Burt, 1931, p. 200 (*Eurycea b. bislineata*); Burt, 1932, p. 76; Cope, 1889, p. 163–68; Davis, 1884, p. 13; Deckert, 1914; DeKay, 1842, p. 79 (*Salamandra bilineata*); Ditmars, 1905, p. 173 (*Spelerpes bilineatus*); Dunn, 1918, p. 470 (*Eurycea bislineata*); Dunn, 1926, p. 304 (*Eurycea b. bislineata*); Eckel and Paulmier, 1902, p. 401 (*Spelerpes bilineatus*); Eights, 1835, p. 61 (*Salamandra bislineata*); Evermann, 1918, p. 50 (*Eurycea bislineata*); Fowler and Dunn, 1917, p. 20 (*Spelerpes bislineatus*); Hamilton, 1932, p. 86 (*Eurycea b. bislineata*); Leffingwell, 1926, p. 72 (*Eurycea bislineata*); Mearns, 1898, p. 323 (*Spelerpes bilineatus*); Mearns, 1898*a*, p. 345; Myers, 1930, p. 101 (*Eurycea b. bislineata*); Noble, 1927, p. 3 (*Eurycea bislineata*); Reed and Wright, 1909, p. 403 (*Spelerpes bislineatus*); Sherwood, 1895, p. 31 (*Spelerpes bilineatus*); Smallwood, 1928, p. 94 (*Eurycea bislineata*); Weber, 1928, p. 108 (*Eurycea b. bislineata*); Wilmott, 1933, p. 163 (*Eurycea bislineata*); Wright and Moesel, 1919, p. 64; Wright and Haber, 1922, p. 32; Yarrow, 1882, p. 156 (*Spelerpes bilineatus*); 5th Ann. Rep't State Cab. Nat. Hist. 1852, p. 21 (*Spelerpes bilineata*); 7th Ann. Rep't State Cab. Nat. Hist. 1854, p. 26; 46th Ann. Rep't N. Y. State Mus. 1893, p. 22 (*Spelerpes bilineatus*); 61st Ann. Rep't N. Y. State Mus. 1908, p. 132; 62d Ann. Rep't N. Y. State Mus. 1909, p. 99.

General. Holbrook, 1842, p. 55–56, pl. 16 (*Salamandra bilineata*); Goodale, 1911, p. 173–247, figs. 1–77, 1 pl. (*Spelerpes bilineatus*); Koehring, 1925, p. 250–64, pls. 1–2.

EURYCEA LONGICAUDA (Green)

(*Salamandra longicauda,* Jour. Acad. Nat. Sci. Phila., 1818, 1:351)

Long-tailed Salamander

Figures 3*f*, 57*a–b*, 58–59

The long-tailed salamander has been found in only a few localities in New York and is to be regarded as one of the rarer species.

Description

Size. The largest males and females recorded by Dunn (1926, p. 323) were 151 and 158 mm long respectively, the specimens from Jefferson county, Mo., and Hot Springs, Va. In a series collected

at Montour Falls, N. Y., the largest male is 128.5 mm and the largest female 155 mm. Nine adult males averaged only 102.6 mm with the extremes of 100 and 128.5 mm. Five adult females varied from 106.5 mm to 155 mm and had an average length of 133.3 mm.

In the larger, fully adult males and females the tail comprises about 60 per cent of the total length. In the females the variation is within comparatively narrow limits, from 60 to 62 per cent. In the males the tail is slightly shorter and the variation a little more marked, usually from 57 to 60 per cent of the length.

The tail is comparatively short in young individuals and becomes proportionally longer with increase in size. This is well shown in the table given below:

LOCALITY	DATE	SEX	TOTAL LENGTH	TAIL LENGTH	TAIL, PER CENT TOTAL LENGTH
Montour Falls, N. Y.....	May 20, 1933	♀	56 mm	29 mm	51
Montour Falls, N. Y.....	May 20, 1933	♀	63 mm	33 mm	52
Montour Falls, N. Y.....	May 20, 1933	♀	68 mm	37 mm	54
Montour Falls, N. Y.....	May 20, 1933	♀	72 mm	40 mm	55
Montour Falls, N. Y.....	May 20, 1933	♀	95 mm	56 mm	59
Montour Falls, N. Y.....	May 20, 1933	♀	154 mm	94 mm	61
Montour Falls, N. Y.....	May 20, 1933	♀	155 mm	95.5 mm	61

Form. This is a long, slender species, and the only species in the State in which the tail, in the adult, comprises 60 per cent of the total length.

The head is long, and somewhat depressed, widest immediately back of the eyes, gently converging behind to the lateral extensions of the gular fold and tapering abruptly to the rounded and swollen snout. The eyes are large and prominent, the horizontal diameter equal to the distance between the anterior angle of the eye and naris. Viewed from the side, the commissure of the mouth is slightly sinuous, the angle of the mouth extending to a point opposite the hind angle of the eye. Continuing backward from this point there is a well-marked fleshy fold that extends one-third the distance to the gular fold and a short vertical groove to the hind angle of the eye. The gular fold is well indicated though scarcely overlapping and extends on the side of the neck where it is met by a sinuous groove running to the eye. At a slightly lower level, a short groove extends from the gular fold to the insertion of the foreleg.

The trunk is well rounded on the sides, flattened ventrally and provided dorsally with a median impressed line. There are 13 well-marked costal grooves and in some individuals an additional groove in the groin. In a large female, the appressed toes are separated by one costal fold. In some males the appressed toes just meet.

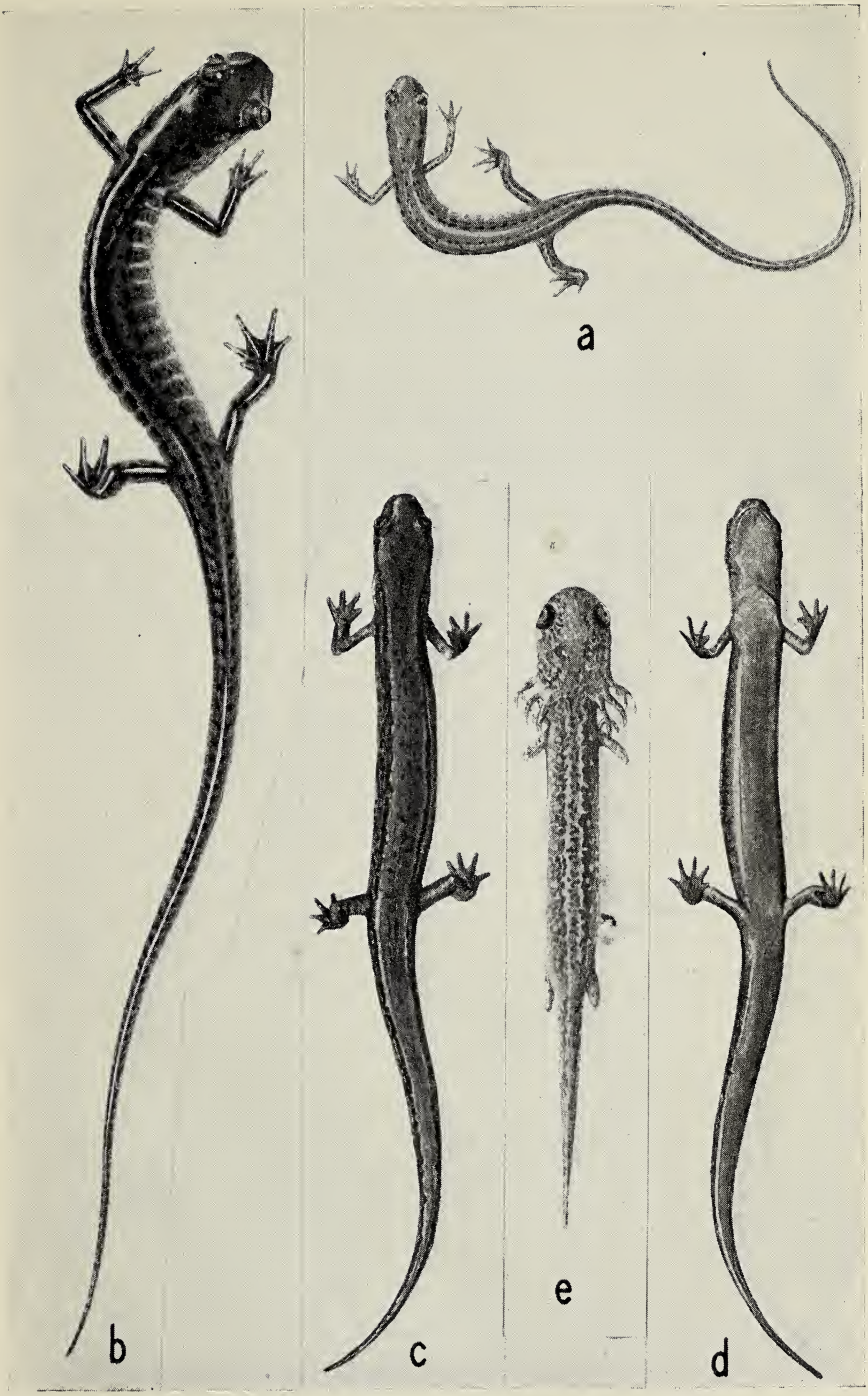

Fig. 57 *Eurycea longicauda*. a. Juvenile, actual length 62 mm., Montour Falls, N. Y. May 20, 1933. b. Adult female, actual length 152 mm. Same data. H. P. C., del. c. *Eurycea bislineata bislineata*. Adult female, actual length 70 mm, Stamford, N. Y. June 25, 1922. d. Same, ventral view. e. Larva at hatching, actual length 12.5 mm, Voorheesville, N. Y. May 31, 1923. E. K. O'B., del.

The legs are well developed, particularly the hind pair, with the toes only moderately long and slightly webbed at base. Toes in order of length are 1-5-2-4-3. Toes of the fore feet are 1-4-2-3 in order of length.

The tail is long, slender, tapering and compressed. At the base it is nearly oval in cross section.

The skin is smooth and shining but everywhere shallowly pitted. There are no large and conspicuous pores on the head.

In the male the vomerine series are long and with the ten to twelve teeth somewhat irregularly disposed. The series originate opposite the inner margin of the naris and curve inward and backward to a point opposite the middle of the eye. The parasphenoid teeth are in two long patches separated narrowly from each other and from the vomerine series by about the length of the latter. In the female, the vomerine teeth are a little closer to the parasphenoid.

The tongue is small, nearly round and boletoid, with the stalk attached at the front.

Color. The ground color is bright yellow or orange, specimens from the North often with much higher color than is usual farther south. Minute black specks temper the ground color and sometimes give a brownish tinge. Scattered over the dorsal surface of the trunk and limbs are many deep brown or black spots of irregular size and shape. These spots tend to form an irregular median line and along the upper sides, where the spots become elongate, they form a fairly regular line which is continuous with a short series extending to the eye. On the upper sides the spots are larger, longer and closer together than on the lower sides. The dark spots are noticeably fewer on the dorsum of the head and the snout, in some individuals, is immaculate. The base of the tail is marked as on the trunk but distally, where there is a noticeable keel, very few of the spots cross the middorsal line. Sides of tail, particularly on the basal half, marked with vertical crescentic or dumbbell-shaped black bars. Sides of the head with a few, small, scattered black spots. The bright orange or brownish orange of the dorsum gradually fades on the lower sides through tones of orange-yellow to clear yellow. The venter and lower surface of the limbs are usually entirely free from dark spots. The throat is flesh-colored with yellowish tinges on the sides and in front of the gular fold. The belly is yellowish along the sides, bluish along the midventral line and with greenish tinges in the region of the liver. The iris of the eye is brassy.

Sexual differences. Sexual differences are not well marked externally. The vent of the male is slightly papillose and the snout is a little more strongly swollen in the region of the naso-labial grooves than in the females. Measurements of a considerable series of specimens of both sexes indicate that the tail of the male is proportionally shorter than in the female but the differences are slight. Usually the appressed toes nearly meet in the males and are separated by at least one costal fold in the females.

In two males from St Louis county, Missouri, and a single male from Montourville, Pa., the edge of the upper lip at the naso-labial grooves is prolonged into rather distinct cirri.

Activities of the Breeding Season

Very little is known of the breeding habits of this species. Morse (1901, p. 115) has reported the species, "in May under stones at the edge of the water together with its eggs; the eggs are attached to the under side of a hollow stone." This statement leaves one in doubt whether the eggs were deposited in water or on land at the edge of the water.

I have dissected a number of females taken in New York State in May and found the ovarian eggs small, none exceeding 1 mm in diameter. The males taken at the same time and place, Montour Falls, had no sperm in the vas deferens. One might judge from this that the eggs had already been deposited and that the small ovarian eggs represented the next season's complement.

Development

Nothing has been written on the individual egg and its envelops, on the length of the incubation period or on the newly hatched larvae. The smallest larvae seen by Dunn (1926, p. 323) was 30 mm long. I have some larvae only 19 mm long sent me by B. C. Marshall of Imboden, Ark., and apparently recently hatched.

The newly hatched larva. These larvae are uniformly pigmented above and on the sides with regularly spaced black chromatophores. The throat, belly, lower surface of the limbs and basal third of the tail below are immaculate. The chin is rather strongly pigmented. The tail is broadly keeled above to a point opposite the insertion of the hind legs and below, more narrowly, to the vent. The gills are rather short, bushy and pigmented. When the larvae have attained a length of about 25 mm, a row of seven or eight small,

round, pigment-free spots appears on the lower side between the fore and hind legs and a second row longer but less perfectly developed, on the upper sides.

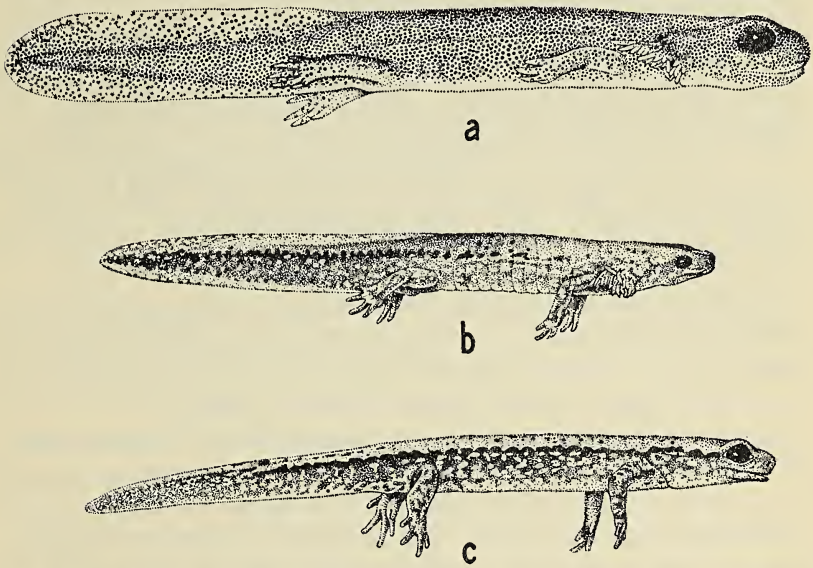

Fig. 58 *Eurycea longicauda*. a. Recently hatched larva, Imboden, Ark. Feb. 16, 1927, actual length, 19 mm. b. Full-grown larva, Imboden, Ark. July 1933, actual length, 60 mm. c. Recently transformed, Imboden, Ark. July 1928. Actual length, 44 mm. H. E. R., del.

The mature larva. The largest larva measured by Dunn (1926, p. 323) was 43 mm long. A larva in my own collection is 60 mm long with the tail comprising 50 per cent of the length. In this fully grown larva there is a broad, light dorsal band within which are a few scattered black spots and many fine specks. The dorsal band is limited on either side by an incomplete row of dark spots which extend along the sides of the trunk and the tail to its tip. The sides of the trunk and tail have many small, irregular, pigment-free spots arranged more or less in lines. On the sides of the tail, the light areas tend to form a vertical series that doubtless, in the adult, become the interspaces between the vertical black bars. The tail fins, the legs above, and the sides of the head are strongly mottled. The gills are moderately long, bushy and strongly pigmented.

The length of the larval period has not been determined.

Transformation. Dunn's smallest transformed specimen was but 44 mm long. My own specimens, apparently recently transformed,

are 45 mm long. It is therefore evident that in this species, as in several others, the fully grown larva may exceed in length some transformed individuals.

The colors and pattern are essentially those of the large larvae. The dorsal light band is more prominent and the separate dark spots, which limit the sides of the band in the larva, form a continuous line in the transformed individuals. The sides of the head and trunk are mottled with brown and pigment-free areas and the tail begins to show some segregation of pigment in the form of vertical bars. The chin is quite strongly pigmented and the throat, belly and lower surface of the tail have a few scattered chromatophores. The tail fin is lost below and reduced to a low keel above on the distal half.

Development to maturity. Not enough specimens have been collected at any one time or place to give a clear idea of the growth rate and age at sexual maturity. The smallest mature male dissected was 100 mm long and the smallest female, 95 mm.

In a series of ten transformed specimens from Montour Falls, N. Y., taken May 20, 1933, the size range was from 63 to 155 mm. Four of the ten specimens varied from 56 to 72 mm and may well represent a single age group. The remaining specimens varied from 95 to 155 mm, with no clear indication that more than one age group was represented. It is possible, of course, that the three smaller specimens, 95, 100 and 104 mm in length respectively, belong to one class and that the others, 128.5, 154 and 155 mm long, represent a second.

Habits

General. The adults are nocturnal and usually terrestrial during the greater part of the year. When exposed in their retreats, they often remain inactive or attempt escape by crawling slowly away. When disturbed, however, they are capable of active movements and will run rapidly over the ground, aided by the long tail which is thrown violently from side to side.

The adults can swim and voluntarily take to the water on occasion but they are more at home on land and are much less aquatic than their smaller relative, *E. b. bislineata.*

Food. Surface (1913, p. 101) examined the stomach contents of 45 specimens and reported, "spiders, mites, pseudo-scorpions, thousand-legged 'worms,' various forms of insects, and vegetable matter such as grass."

Habitat

I have collected the adults only in terrestrial situations. In the valley of the Loyalsock, in Pennsylvania, eight adults were taken August 3, 1924, in and beneath old rotting logs lying in an open meadow bordering a small stream. A few were recovered from beneath stones (Bishop, 1925, p. 11). At Montour Falls, N. Y., ten transformed specimens were taken in the course of an hour from the crevices in a shale bank and from beneath stones and rock fragments near the foot of a small waterfall.

Several early writers (DeKay, 1842; Smith, 1882, etc.) regarded the animal as essentially aquatic but the former knew the species only from a single preserved specimen and Smith apparently had little experience with it. Holbrook (1842, p. 62) quoted Green, the describer, as having seen the animal in water but, with considerable discernment judged it to be generally terrestrial. That the adult long-tailed salamander sometimes enters the water voluntarily is not to be questioned for Dunn (1926, p. 324) took both adults and larvae in and around springs in Pennsylvania and Virginia. Further, the adults seemed thoroughly at home and acted much like larvae.

This species has also been reported from caves (Cope, 1889; Hurter, 1903, 1911; Ditmars, 1905; Surface, 1913) and a few may have been taken in such situations but, as Morse (1904, p. 113) has pointed out, it is not distinctly a cave animal. The common name, cave salamander, which has been applied to this species belongs more properly to *Eurycea lucifuga* and *E. melanopleura* with which the long-tailed salamander has sometimes been confused.

The majority of transformed individuals will be found in terrestrial situations and usually where there is evidence of moisture. Ditmars (1905, p. 175), "took large numbers of specimens along a mountain stream, at the Delaware Water Gap, Pennsylvania. They were hiding under flat stones in the bed of a nearly dry stream." Morse (1904, p. 113) observed that the species is generally found away from water and on being disturbed seldom runs toward it, and usually in the opposite direction. Specimens I have taken along the margins of streams have never made for the water but sought to escape by burrowing beneath loose surface materials. Hassler (1932, p. 95) reported three specimens found clinging to the inner wall of a concrete catch basin near Portville, N. Y. The salamanders were several inches above the surface of the water. Another specimen was found among stones and rubble at the base of a spring house where small streams seeped through a wall. A single specimen was taken

from beneath a stone about 30 feet from a stream and another was lying under a damp board about 40 feet from the water. A single individual was found crawling through wet grass during a rainstorm at night.

Range

New York to Georgia and westward to southern Missouri and Arkansas.

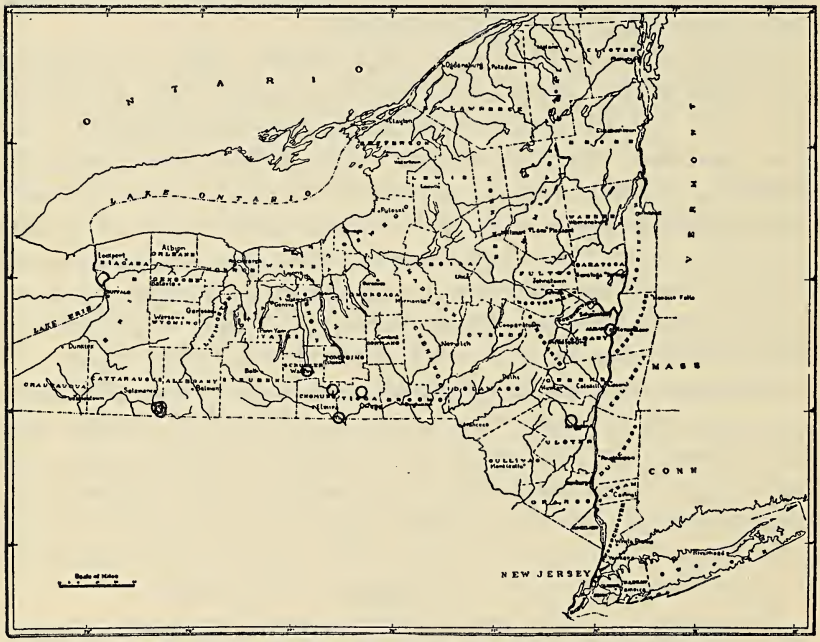

Fig. 59 New York localities for *Eurycea longicauda*.

Distribution in New York

General. Formerly taken as far north as Albany, now apparently restricted to the southern tier counties.

Specific records. ALBANY: *Albany* (DeKay, 1842; Allen, 1869; Bishop, 1923); 1 spec., New York Lyceum (Lindsay, 1844). CATTARAUGUS: *Bedford Corners,* June 14, 1931, 1 spec., A. M. N. H. No. 38057 (Hassler, 1932); near *Portville,* Feb. 3, 1931, 3 ads., A. M. N. H. No. A38055 (Hassler, 1932); *Lillibridge creek,* May 14, 1931, 2 ads., U. R. No. 1462 (Hassler, 1932); *Lowe farm,* Feb. 18, 1931, 1 juv., A. M. N. H. No. A38056 (Hassler, 1932). CHEMUNG: 4 mi. S. of *Van Etten,* Oct. 5, 1935 (A. H. Wright). SCHUYLER: *Aunt Sarah's Falls,* near Montour Falls, Sept. 20, 1932, sev. spec. (J. A. Weber); May 20, 1933, 10 ads. and juv. (S. C. B. and A. S. B.); May 2, 1934, 4 ads. TIOGA: *Candor,* Aug. 26, 1935, 1 juv.; Oct. 5, 1935, 4 yg. (A. H. Wright); 4 mi. west of *Waverly,* about 1920 (W. A. Hilton). ULSTER: *Ashokan,* 1 spec., A. M. N. H. No. 2518 (Dunn, 1926).

Records too indefinite to be placed under counties. Near New York City (DeKay, 1842; Baird, 1850; Allen, 1869). Listed from New York but without locality records (Eckel and Paulmier, 1902, p. 401).

Condensed Bibliography

Life history and habits. Ditmars, 1905, p. 175 (*Spelerpes longicauda*); Dunn, 1926, p. 324 (*Eurycea longicauda*); Hassler, 1932, p. 94; Hurter, 1911, p. 85 (*Spelerpes longicaudus*); Morse, 1904, p. 113; Smith, 1882, p. 728; Surface, 1913, p. 100 (*Spelerpes longicauda*).

Distribution in New York. Allen, 1869, p. 201; Baird, 1850, p. 287 (*Spelerpes longicauda*); Bishop, 1923, p. 67 (*Eurycea longicauda*); DeKay, 1842, p. 78 (*Salamandra longicauda*); Dunn, 1926, p. 325 (*Eurycea longicauda*); Eckel and Paulmier, 1902, p. 401 (*Spelerpes longicauda*); Hassler, 1932, p. 94 (*Eurycea longicauda*); Lindsay, 1844, p. 50 (*Salamandra longicauda*).

General. Cope, 1889, p. 168–70, pl. 28, fig. 1–3; pl. 35, fig. 11 (*Spelerpes longicaudus*); Fowler, 1907, p. 66–69 (*Spelerpes longicauda*); Holbrook, 1842, p. 61–62, pl. 19 (*Salamandra longicauda*); Hurter, 1903, p. 79 (*Spelerpes longicaudus*); Hurter, 1911, p. 81; Morse, 1901, p. 115 (*Spelerpes longicauda*).

DESMOGNATHUS FUSCUS FUSCUS (Rafinesque)

(*Triturus fuscus,* Ann. Nat. Lexington, No. 1, 1820, p. 4)

Dusky Salamander

Figures *3h–i, 4o,* 60–62, *64a–d*

The dusky salamander is perhaps the commonest and most widely distributed species in the State. In its somber markings and obscure pattern it is one of the least striking of all the species.

Description

Size. Measurements of an extensive series of specimens from the vicinity of Rochester, N. Y., have been made by C. P. Zorsch. Ninety adult males varied in length from 65 to 113 mm and averaged 91.2 mm. In this series the tail averaged 46.7 per cent of the total. In a series of 65 adult females, the extremes were 66 to 100 mm and the average 82.5 mm. In the females the tail averages 47.2 per cent of the total. The largest male in the series from Rochester has a total length of 121 mm and the largest female, 100 mm.

Dunn (1926, p. 86) who examined a total of 3165 specimens found that the largest male measured 134 mm in total length and the largest female 107 mm.

It is evident that individual males not only attain a larger size but average larger than the females, and that greater length is in the body rather than in the tail.

Form. This is a stout-bodied salamander with strong legs and a thick fleshy tail. Viewed from above, the head in the adult female appears small for the size of the body. The sides of the head back of the eyes are nearly parallel or slightly swollen and the snout tapers to a bluntly rounded point. In the adult male the head back of the eyes is conspicuously swollen and glandular and the snout more pointed. The eyes are of moderate size and contained 5 to 5½ times in the head length. The horizontal diameter of the eye is equal to the distance from the anterior angle to the nostril. There is a vertical fleshy fold at the posterior angle of the eye under the edge of which the posterior end of the lower lid is concealed. Across the anterior end of the upper eyelid there is a more or less distinct groove. The mouth is fairly large, the commissure of the jaws forming a sinuous line in the male and nearly straight in the female. The angle of the jaws extends behind the eye a distance equal to the diameter of the eye. The gular fold is well developed and continued on the sides of the neck. There is a well-marked horizontal groove extending from the eye to the lateral extensions of the gular fold which is crossed by a short vertical groove at the angle of the jaws. A median impressed line extends along the back from the back of the head to a point above the hind legs.

In the majority of specimens there are 14 costal grooves with one in the axilla sometimes forked above, and 4 to 4½ intercostal spaces between the appressed toes. In some, the costal grooves are continued on the back and arch sharply forward to meet the middorsal line. The tail is stout at base, trigonal in cross section and tapering to the slender tip. The distal third or half is strongly compressed and usually thinly keeled above. The hind legs are longer and larger than the fore and have the toes 1-2-5-4-3 in order of length. The fore feet have the toes 1-4-2-3 in order of length, the first only one-half the length of the next shortest, the fourth.

The vomerine teeth are present in the female but usually lost in the adult male. Exceptions may be noted, however. An adult male 77 mm long from Corbett's glen, Rochester, N. Y., has the vomerine teeth well developed (figure 3h). On dissection, the male was found to have the vas deferens packed with sperm. When present in the male, the teeth form two short curved series which originate opposite the inner angles of the nares and curve inward and backward, separated posteriorly by about the diameter of a naris and as far again from the parasphenoid teeth. The latter are in two long, club-shaped patches separate throughout their length. The vomerine series in

a

b

c

d

Fig. 60 *Desmognathus fuscus fuscus.* a. Female guarding eggs, Stamford, N. Y., June 25, 1922. Note the "nestlike" arrangement of the roots evidently formed by turning movements of the female. b. Adult in water showing characteristic pose assumed when in repose. c–d. A female and her brood of recently hatched young. Sept. 3, 1927. The young remained with the mother for several days, usually in contact with her body.

the female form two more sharply converging lines of five to seven teeth which are separated from the parasphenoids by about the diameter of a naris. The parasphenoid patches may be separate, or more or less united anteriorly and divergent behind.

The tongue is rather small, broadly oval in outline and with fine plicae radiating toward the front and sides from the posterior third. It is attached medially in front and has the sides and posterior part free.

Color. There is considerable variation in the intensity of the pigmentation and loss of a well-defined pattern in the older and darker specimens. The typical pattern consists of a broad dorsal band with irregular edges, lighter than the adjacent sides and more pronounced on the posterior part of the trunk and basal third of the tail. The ground color above varies from a fairly light yellowish brown to deep seal brown and black. In many individuals, the dorsal band is brown mottled with darker wormlike or circular markings inclosing lighter spots which are the remnants of the dorsal light spots of the larva. The upper sides next to the dorsal band are dark brown to black, fading gradually to the level of the legs and there becoming lighter and somewhat mottled. The throat, belly, lower surface of the limbs and tail are flesh-color in life, tinged with bluish and varied by small, light, pigment-free spots which impart a delicate mottled appearance. The midline of the venter in some individuals is immaculate and in general the whole ventral surface is conspicuously lighter than in *D. o. ochrophaeus*.

In many juveniles and young adults the basal half of the tail above is marked with a bright chestnut band with irregular black edges.

Sexual differences. The males differ from the females in their greater average size and in well-marked structural features. The broader and longer head of the male is noticeable and the lower jaw is produced into a round-pointed lobe on which there is a conspicuous mental gland. The sides of the head and neck, the posterior half of the lower eyelid, the area between the eye and the nostril and the chin, in breeding males, are glandular. In the females there are a few enlarged pores on the side of the snout between the eye and nostril but they are not developed to the extent found in the males. The hind legs of the male are proportionally and actually a little longer than in the female. As indicated in an earlier paragraph, the vomerine teeth are usually lost in the adult male and both Dunn (1926, p. 83) and Noble (1927, p. 8) have described the elongated teeth of the premaxilla. The cloacal lips of the male are provided with villi while those of the female are thrown into narrow folds.

Activities of the Breeding Season

Migration. The dusky salamanders commonly live in or within a few feet of streams or springs and while occasionally found wandering at night they are not known to undertake extensive migrations.

Mating. Wilder (1913, p. 257) was the first to observe and put on record an account of the mating habits, and, although some of her observations have since received a different interpretation, they are of interest as being the first to mention spermatophores. She says:

On the evening of May 13, 1908, I isolated in a small terrarium a large male, and a female through the abdominal wall of which large eggs could be seen. It was discovered the next morning, however, that another smaller male was also present in the terrarium, probably having been carried over unobserved in transferring some wet leaves. On the following morning, May 14, the female and this smaller male were found lying upon the earth under some wet leaves, the ventral surfaces of their bodies in contact. They reacted so quickly, however, to the disturbance of the leaves that beyond this very hasty observation as to their general position I can state nothing definite as to methods of clasping or exact regions of contact. Protruding from the cloaca of the female was a yellowish, semi-fluid mass which was found upon examination to be a spermatophore of very soft consistency.

In view of the close association of the sexes and the presence of the spermatophore in the cloacal lips of the female, Wilder assumed that direct transference of the spermatophore might have been the method of insemination; and it is, of course, possible that this method is employed under some circumstances.

More detailed observations on the courtship of the dusky salamander, under laboratory conditions, have been given by Noble and Brady (1930, p. 53) who found that, in general, it followed the pattern of other plethodontids, an outline of which is given under the account of the four-toed salamander (p. 174).

Spermatophores. Ten years after her first account of spermatophores, Wilder (1923, p. 89) again reported their occurrence as irregular, creamy white masses of spermatozoa found in the shallow water of a crystallizing dish in which adults were confined. At the same time a female was found carrying a portion of a spermatophore in the lips of the cloaca. The specimens were collected May 14th to 16th and the partially formed spermatophores appeared May 20th. The discovery of these structures in water led Wilder to the assumption that, "both the direct and the indirect method of impregnation

of the female (might) obtain in this species, the former operative when the individuals find themselves under purely terrestrial conditions, the latter, which is of course the more primitive method, being employed under aquatic conditions."

The observations of Noble and Weber (1929, p. 3) have cleared up several doubtful points with respect to the place of deposition of the spermatophores and the form of the complete structure. Specimens taken June 16, 1928, from a cold spring near the Delaware Water Gap, Pa., and confined in covered glass dishes with water, moss and leaves, deposited spermatophores on the surface of leaves out of water, June 18th. Two additional spermatophores were found June 28th. The sperm cap of a spermatophore was noticed October 28th in the cloaca of a female taken the day before at Morristown, N. J., and in a series of adults from Yonkers, N. Y., taken November 8, 1928, a female had a spermatophore protruding from the cloaca. Among some preserved specimens a female from Coytesville, N. J., taken March 31, 1928, was found with the head of a spermatophore in the posterior part of the cloaca.

In my own experience with the species spermatophores have been found both in the fall and spring. On March 19, 1933, several specimens from Corbett's glen, Rochester, N. Y., were confined together in a glass jar with damp leaves and the following morning complete spermatophores and those with the sperm caps removed and held in the cloaca of females were found. On October 6, 1933, several more specimens from the same locality provided additional material. In one female the sperm cap was held at the anterior end of the vent.

Noble and Weber (1929, p. 3, figure 1*a*) describe the fresh spermatophore as having "a glassy transparent base surmounted by a small, whitish cap." If the spermatophore figured is typical it is evident that there is much variation in the size and shape of the structure. In my own specimens the gelatinous part is greatly expanded to form a flangelike base while the tip is comparatively slender and surmounted by a thimblelike sperm mass that fits over the conical top like a cap. The sperm cap shows a laminated structure and in this respect differs from that of *Desmognathus o. ochrophaeus*. The height of the complete spermatophore is approximately 3 mm and the expanded base 2½ to 3 mm.

The egg-laying process. The deposition of the eggs under natural conditions was reported by Hilton (1909, p. 535) but not described. A female was found beginning the deposition of eggs in the early morning and continued laying after being transferred to

the laboratory. Noble and Evans (1932, p. 2) induced a considerable number of females to deposit eggs in the laboratory following pituitary transplants, but gave no account of the actual laying.

The egg mass. The eggs are normally deposited in a compact mass; the outer envelop of the individual eggs drawn out into a tube or stalk and united with one another in small clusters. Eggs in close contact often cling by the adhesiveness of the outer envelop and those at the periphery have the stalk drawn out and twisted.

There is considerable variation in the number of eggs composing the complement of single females. Those I have found under natural conditions varied from 12 to 26 with the average 17. Hilton (1909, p. 535) writes:

> The eggs are about fifteen or twenty in number, usually grouped together in a single package under logs or stones in moist, or rather wet locations with the body of the female arched about them in the form of a semicircle. . . . The small cavities under logs and stones where the female is half coiled about the eggs, are not far from water, usually near a small brook or spring, and in many cases are well hidden under piles of stones or deep down in the loose earth under some completely buried log or stone. In other cases the eggs and females may be found in partly deserted creek beds where the water seldom comes except at flood time. Here they may be under some of the slabs of shale which have been split off from the bed rock by frosts, but still remain in position.
>
> The eggs were found in a single bunch or in two bunches close together; in no case were they wrapped about the body of the female. Almost always they were within the semicircle formed by the female's body.

My own observations confirm those of Hilton and are at variance with those of Baird (1850), Cope (1889, p. 197), H. H. Wilder (1899, p. 237), I. W. Wilder (1913, p. 269) and others who describe the eggs as deposited in the form of a rosary and wrapped about the body of the female. Wilder (1899, p. 236), however, illustrated his paper with a figure showing the female curled in a semicircle about a compact cluster of eggs with nothing to indicate a rosary-like string.

The count of ovarian eggs sometimes approximate the number found in the field but often exceeds it. Wilder (1913, p. 260) found the number to average about 20 in the field and her dissections indicated that 10 or 11 were usually found in each ovary. In a series from Haverford, Pa., collected by Dunn (1926, p. 91), females approximately 80 mm long usually had 28 eggs in the ovaries, while larger females up to 100 mm had as many as 40.

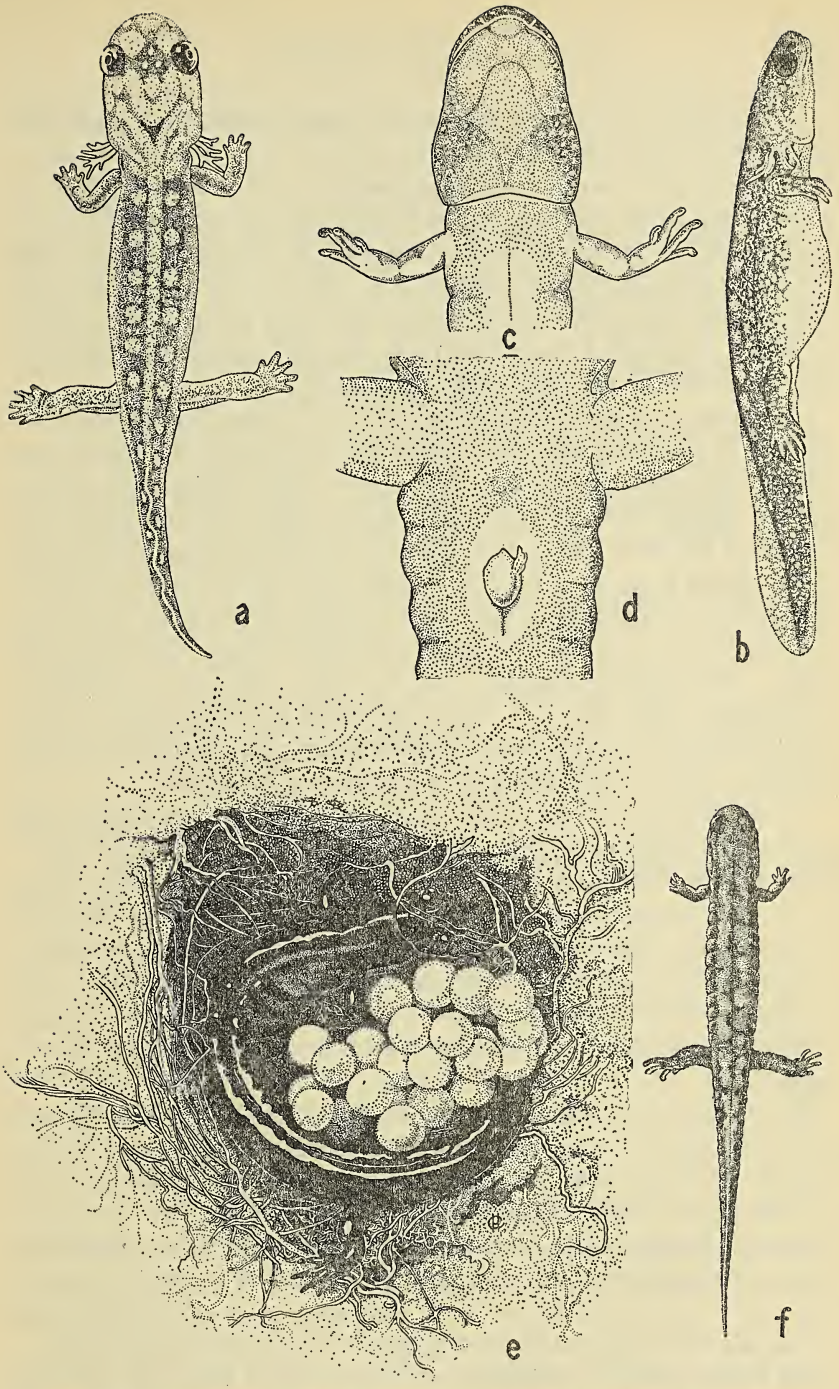

Fig. 61 *Desmognathus fuscus fuscus.* a. Larva at hatching, Conneaut lake, Pa., Aug. 25, 1925. Actual length 16 mm. H. P. C., del. b. Same, side view, H. P. C., del. c. Lower side of head of adult male, to show the contour of the jaw and mental gland. H. M. Z., del. d. Female with spermatophore held in anterior end of cloaca. H. M. Z., del. e. Female guarding eggs in nest, Stamford, N. Y. June 25, 1922. H. P. C., del. f. Juvenile, Bushnell Basin, N. Y. Feb. 20, 1931. Actual length, 52.5 mm. The light spots of larva, by expansion and coalescence, give rise to juvenile pattern.

In choosing a nest site, the female dusky salamander need not depart from the retreats that have already provided food and shelter. Any object on the surface or imbedded in the ground may serve as a cover and often the eggs are deposited beneath accumulations of dead leaves or layers of moss. Sometimes a natural cavity will serve the purpose but occasionally it is evident that the female has been directly concerned in the preparation of a suitable nest. The situations in which I have found the eggs are briefly described to give some idea of the wide choice exercised.

On June 25, 1922, at Stamford, N. Y., a large female was discovered beneath the edge of a large, flat stone near the margin of a small, open meadow stream. Here there was a definite excavation and the matted roots of grass and meadow plants twisted about the margin of the nest, gave every indication of the turning movements of the female in gouging the hole in the soft soil (figure 61 e). The nest and its contents were then photographed in the field and, with a clump of the surrounding soil, transferred to the laboratory for study. The female remained with her eggs, shifting her position occasionally, until July 7th, when the entire lot disappeared. The bulging contours of the female indicated what had happened to the eggs and they were subsequently recovered by dissection.

Where thick moss covers the mucky soil of a springy swamp the females sometimes congregate in numbers. In such a situation three females, each with eggs, were found July 26, 1922, at Voorheesville, N. Y. The three lots occupied a small area eight inches across and were placed in little hollows in the black soil. In the same swamp a female with eggs was found July 31, 1923, beneath a layer of sphagnum moss several feet from a spring; another batch of eggs without the attendant female, beneath a stone at the edge of the spring.

The nests are not always on or in the ground. At Van Etten, N. Y., August 4, 1924, two females each with 16 eggs were found beneath the loose moss and bark covering a log that extended over and about ten inches above, a small swamp stream. On the same date near Stevenson, Pa., a large female was found coiled about her eggs in a rounded cell in the ground by the side of a hillside spring. The cavity 1¼ inches across by 1 inch deep gave every indication of having been excavated by the female and was concealed by a small board partially imbedded in the wet soil. The eggs may be found in greatest numbers, however, by visiting some dwindling stream where it wanders through open woods. Here, beneath the accumulation of old rotting leaves and the stones of the bottom, the

females are sometimes revealed by the dozen by the simple expedient of rolling back the matted layer of debris.

Development

The egg and its envelops. The eggs vary somewhat in size when encountered in the field and the difference is, in some instances, to be correlated with the size of the female, a large individual depositing more and larger eggs than a small one. On the other hand, the amount of moisture present at the nest site and absorption by the egg envelops must also be considered as a factor.

The outside diameter of eggs deposited under natural conditions in the field varies from 3 to 4½ mm. The smaller eggs were found with a very small female. This size is sometimes exceeded by the yolk alone in larger eggs which sometimes has a diameter of 3½ mm, but, more often, does not exceed 3 mm.

The individual eggs have been described a number of times and there is general agreement in the interpretation of the several envelops. In addition to the vitelline membrane the yolk is surrounded by three separate envelops, the first usually having a greater diameter than the others and composed of clear jelly; the layer next without is comparatively thin and again jellylike. The outermost layer is thin, tough and elastic and is drawn out in the form of a tube or twisted string to form the attachment to other eggs.

The yolk is without pigment and the color usually dead white above and slightly yellowish below.

The incubation period. Hilton (1909, p. 536) has indicated that the eggs appear to be found in greatest abundance from the last of June to the middle or the last of July. Reed and Wright (1909, p. 404) indicate July as the time of maximum egg laying. Wilder (1913, p. 260) writes, "As reported by H. H. Wilder ('04) eggs have been deposited by individuals in captivity in the Smith College laboratory as early as June first. It is thus safe to state that the egg-laying period extends at least from the first of June to the last of August and possibly through September." Wilder indicates that the eggs found September 24th in western Massachusetts were at the point of hatching and that they probably were deposited the latter part of August.

Sherwood (1895, p. 34) thought there were two broods annually and reported eggs found from July to October. The length of the incubation period during which the female remains with the eggs would very likely preclude the possibility of two broods, and the

October date for eggs doubtless refers to well-advanced embryos still retained in the envelops, if, indeed, the eggs found at this late date belonged to *Desmognathus f. fuscus.*

The incubation period has been variously estimated to extend from five weeks (Wilder, 1913, p. 267) to approximately eight weeks (Wilder, 1917, p. 18; Dunn, 1926, p. 92). The period of incubation for two sets of eggs carried through to hatching by Wilder (1917, p. 18) was 53–55 and 56–57 days. Noble and Evans (1932, p. 12) gave 50–52 days as the length of the period under laboratory conditions but also recorded five sets of eggs laid June 15th, 18th and 22d which hatched July 30th or 31st, a period in this instance of 46 days at the outside. It is altogether probable that the period is variable, depending in large part on temperature.

The hatching period for any single lot of eggs may be limited to a single day or extend over several. The hatching period for a batch of 26 eggs taken August 14, 1927, extended from August 15th to 20th. Another lot taken at the same locality and time hatched September 2d, and was promptly devoured by the female that had been in constant attendance.

The newly hatched larva. I have measured 50 larvae of *Desmognathus f. fuscus* collected just as they hatched August 25, 1925, and found a variation in length from 15 to 17.5 mm, with the average, 16.2 mm.

The young larva is well endowed with yolk that imparts a yellowish color to the sides and abdominal region and a decided bulge to the belly. The general tone of the pigment is gray or brown, concentrated somewhat in a broad dorsal band that extends from the back of the head onto the basal half of the tail. Within the dark dorsal band, but separated by a narrow light vertebral line, are paired, rounded, light spots forming distinct series that extend from the shoulders well onto the tail. The sides of the trunk are distinctly mottled to about the level of the legs, the sides of the head to the level of the jaws and the tail to the base of the very narrow ventral fin. There is some concentration of pigment to form a large dark blotch of irregular form between the eyes and a smaller spot on the back of the head. The legs are mottled above like the sides. The ventral surface is without pigment.

The head is broad with the sides nearly parallel back of the eyes. The snout is rather short, the sides converging to the somewhat truncated tip. The eyes are large and prominent. The legs are proportionally large and strong and support the little salamander

immediately after hatching. The toes are fully differentiated. The tail is keeled above from a point opposite the posterior end of the vent, below, narrowly on the distal half. Noble (1931, p. 56) writes of the recently hatched individuals, "The tail lacks a fin," and by this statement lays himself open to the suspicion that he has not seen the larvae of *Desmognathus f. fuscus* hatched under natural conditions. As a matter of fact, the tail fin is fairly well developed before the larva escapes from the egg envelops.

Length of the larval period. Under natural conditions, the eggs are deposited in the proximity of water, and, by burrowing in the soft and yielding soil or by following little crevices downward, the larvae eventually reach the water and make their way to shallow portions of the streams or pools.

The length of the terrestrial larval period varies considerably depending on the location of the nest in relation to the water, the character of the nest site, whether in a very moist or fairly dry situation, and in part on the nature of the season, whether dry and cold or warm and wet.

Nests in saturated soil may be abandoned by the young in two or three days; in drier situations the young may remain in the nest and be attended by the female for a considerable period. Wilder (1913, p. 293) estimated the somewhat variable period of terrestrial life as one to two weeks and the date of beginning of the aquatic period as hardly earlier than the middle of July and possibly as late as the middle of October. Noble (1931, p. 56) says of the recently hatched individuals, that they remain on land, or at least with their heads out of water, for 15 or 16 days. Noble and Evans have also shown (1932, p. 8) that under laboratory conditions, at least, the larval life is plastic and that either the terrestrial or aquatic stage may be omitted. Those reared on damp moss, however, failed to attain the size of those reared in water and remained darker.

There is every reason to believe that under natural conditions the majority of larvae reach the water and continue their development in that medium. It is hardly conceivable that access to water would be impossible in view of the disposition of the eggs in such close proximity to streams and springs and the activity of the young larvae immediately after hatching.

In her detailed studies, Wilder (1913, p. 294) found that the aquatic larval period normally extends through autumn, winter and spring, a period of eight to ten months, with the majority of larvae entering the water in early September.

In my own experience, the majority of eggs have been found to hatch in August, with a considerable number holding over well into September. In view of the fact that recently transformed individuals have been found at Rochester as early as March 12th, it is not improbable that in this region, at least, the entire larval period may be limited to seven months.

At Bushnell Basin, near Rochester, the larvae attain an average length of about 23 mm in February, with extremes of 21 and 28 mm. By the first week in April the average length has increased to approximately 31 mm, with extremes of 28 and 36 mm.

The larval period is spent in the shallow margins of small streams, pools and springs. They are often to be found in large numbers beneath the small flat stones and leaves at the bottom of woodland streams. Where spring-fed streams spread their shallow waters over sandy, weed-grown bottoms, larvae may be collected by the simple expedient of pulling the weeds and washing them in a pail of water.

Mature larvae. Fully grown larvae may attain a length of 44 mm (Dunn, 1926, p. 92), but this is exceptional and the great majority are shorter. The largest larva examined by Wilder (1913, p. 294) was 33 mm long and the average of several only 25.17 mm. My own material indicates that the larvae attain a considerably larger average size in the vicinity of Rochester than in Massachusetts where Wilder studied the species. This is shown by measurements of some specimens taken in April, the largest of which had reached a length of 36 mm and the average 31 mm. A collection made May 11, 1934, contained individuals from 25 to 31 mm long and the lot averaged 27.8 mm.

The dorsal pattern of the fully grown larva is a modification of the early larval pattern brought about by the expansion and coalescence of the paired light spots. The coalescence may be incomplete leaving a series of pale spots narrowly margined on the mesal side with black and narrowly separated by the light vertebral line; or, in the more complete union of the pale spots their outlines may be lost, and only an irregular and broken line of black pigment remains along each side of the vertebral line. On the basal half of the tail above, a median light colored area may be well outlined by narrow, crenulate lines of black. The light area is often bright chestnut but varies from pale yellowish brown to dark brown.

The limbs are mottled above with dark gray and white in a rather coarse pattern but on the sides of the head, trunk and tail the chromatophores are more evenly distributed and fade gradually into the pale

venter. The keel of the tail thins to a knife edge only on the distal half but is continued forward almost to the base as a thickened ridge. The head is broadest just in front of the gills, tapers gently to the eyes and then more abruptly to the truncated snout. The snout is usually dark except in the region of the developing naso-labial grooves and there is a dark spot on the midline of the head just back of the eyes and another near the back of the head.

Transformation. In Massachusetts, Wilder (1913, p. 295) found that, in general, the larvae transformed in June at an average length of about 29 mm. In the region about Rochester, the period during which transformation may take place is much longer, and recently transformed individuals only 28 mm long have been found as early as March 12th.

In its color and markings the recently transformed individual does not differ markedly from the mature larva and there is about the same amount of variation, some individuals retaining the larval markings well defined while in others the general darkening of the ground color obscures the pattern of light dorsal spots.

Conspicuous external changes accompanying transformation may be seen in the narrower head, the longer tail, the reduction of the tail fin, the loss of the gills and in the development of the eyelids.

Transforming individuals are usually to be found at the margins of small streams, pools and springs, not actually in the water but among wet leaves or beneath stones in thoroughly wet situations.

Development to maturity. Wilder (1913, p. 322) writes concerning the transformed individuals:

Specimens collected at any one time do not show sufficient evidence of falling into distinct groups as to size to suggest definite yearly amounts of growth, with the possible exception of the small sizes which, in the case of those collected in the late spring, for example, fall into groups averaging 33 mm, 43 mm, and 56 mm in length, the former recently metamorphosed, and the others presumably adults of one and two years' growth respectively.

A recent study (C. P. Zorsch in mms) of 411 specimens including juveniles and adult males and females from vicinity of Rochester, all taken during the period from November to April, indicates that in this region, at least, well-marked age groups may be recognized. The series includes transformed individuals ranging in total length from 28 to 121 mm. In any series of specimens, a large number will be found with mutilated tails in various stages of regeneration. In the present series were 154 such individuals and in plotting the

growth rate, body length measured from the tip of the snout to the posterior end of the vent, was used.

In the series studied, the majority of juvenile specimens was taken February 20, 1931, at Bushnell Basin, N. Y. In these there is a variation in total length from 44 to 61 mm and in body length from 24 to 34 mm. When body lengths are plotted, the resulting curve shows two high points, one at 28 mm and the other at 30 mm, which very likely indicate a difference in sex. These specimens form a compact group and the members undoubtedly transformed in the spring and early summer of 1930. Taking into account the variation in time of transformation, they may be regarded as eight to ten months old.

The sexually mature males and females vary in total length from about 65 mm upward and in body length from 36 to 66 mm. When the measurements of body length are plotted, there is a definite mode at 42 mm and another at about 46 mm, again representing a difference in sex, the males averaging a little longer.

From these measurements it seems evident that sexual maturity may be reached when the salamanders are 24 to 26 months old, and mating and egg laying may follow a month or two later.

The group of specimens with body length in excess of about 50 mm represent individuals in their third year or older, but the curve beyond this point is very irregular and does not suggest a definite difference in sex or year groups.

Habits

General. In common with the majority of our species, the dusky salamander is mostly nocturnal. During the day it usually remains in hiding beneath some sheltering object near the margins of springs and streams. It is a most active species when disturbed and rushes away, frequently taking refuge in the water where it seeks to hide beneath some object on the bottom. The species is an active burrower and in soft and yielding soil excavates long tunnels into which it often retreats when disturbed. It climbs well and at night may sometimes be found on the sides of stones or in low vegetation.

Many specimens are found with imperfect tails which might indicate that a portion may be readily dropped, but I have never observed any particular tendency toward autotomy in specimens handled. When grasped they writhe and twist and sometimes attempt to bite but do not often part with the tail.

The species is active throughout the year if living by springs or the margins of spring-fed streams. In very cold water it becomes

inactive, but the majority of specimens I have collected during the winter months were not actually in water.

Food. Surface (1913, p. 106) examined the stomachs of 521 specimens of which 235 contained food. This consisted of earthworms, snails, slugs, spiders, mites, insects and their larvae and vegetable matter. Wilder (1913, p. 324) listed the stomach contents of 18 adult specimens, and from her account the following has been summarized: the stomachs of two individuals contained moulted skins, presumably their own, and two had each taken one *Desmognathus* larva. The other food items consisted of caddis flies, dipterous larvae, spiders, ant, mite, beetles, hymenopterous insects, sowbugs, caterpillar, small annelid, crustacea, earthworm and *Gammarus*. Wilder (*ibid.*, p. 280) also found that the young larvae frequently began to feed before the yolk had been exhausted, the food consisting mainly of copepods and insect larvae. The most recent study of the food of this species is that of Hamilton (1932, p. 86), who has indicated the relative amounts of various food items by the percentage-by-bulk method. "Forty-three animals were opened. Stone-fly nymphs, 21.5; annelids, 15; centipedes, 13.7; lepidopterous remains, 11; beetles, 9.4; cast skins, 8.1; miscellaneous insects, 7.9; ants, 3.5; and foreign matter, 7 per cent. A trace of hemipterous parts, a few mites, spiders, tipulids and snails were present. Several specimens were taken under water. These were feeding largely on aquatic forms."

Habitat

The dusky salamander is terrestrial as an adult in as much as it spends most of its time not actually in water but in the proximity of it. It is terrestrial in its mating habits, and the spermatophores and eggs are deposited on land. It may be regarded as aquatic to the extent that it sometimes enters the water voluntarily, swims strongly, and can remain for a considerable period below the surface. The greater part of the larval life is spent in water, but as the time of transformation approaches, many hours are spent with the head and fore part of the body above the surface.

The species is perhaps most abundant along the margins of small wooded streams where stones, logs, bark and other debris on the ground provide hiding places and an abundance of food. They abound on springy hillsides, where water seeps through gravelly slopes, in shallow weed-choked streams with sandy bottoms and in low boggy places. In the winter I have found them in the crevices of and

beneath old logs lying in the bed of a shallow spring, among rotting leaves in the beds of partially dry streams and in the crevices of shale banks.

The species is commonly associated with the two-lined salamander, *Eurycea b. bislineata,* though less aquatic than that species, and with the Allegheny salamander, *D. o. ochrophaeus,* the latter more terrestrial. It is also found with the purple salamander, *Gyrinophilus p. porphyriticus,* where the ranges of the two species coincide and the association is frequently fatal to the smaller dusky salamander. At Voorheesville, N. Y., I have found the red salamander, *Pseudotriton r. ruber,* the purple, the two-lined and the dusky in and at the margins of the same small spring.

Wright and Haber (1922, p. 32) mention the dusky salamander as contributing to the diet of the purple salamander, and in my own experience I have found on several occasions that when the two species have been confined together the smaller one frequently disappears.

Remarks

Baird (1850) was perhaps the first to give an account of the eggs of the dusky salamander. Wilder (1899) followed the development of eggs which had been deposited in a laboratory terrarium and gave a brief description of some of the later stages. In a later paper (1904) an account of the early segmentation stages was given. Hilton in the same year and journal, American Naturalist, also studied the segmentation of the egg, his findings confirming those of Wilder. Hilton subsequently (1909) gave a more detailed history of the early development stages. I. W. Wilder (1913) presented a study of the life history of the species, supplementing her account, in 1917, by some observations on the breeding habits including the first record of spermatophores. In 1923, she gave an additional note on spermatophores, which she believed might be deposited either in water, or transferred directly when the animals were in terrestrial situations. Noble and Weber (1929) figured and described the complete spermatophore which they found to be deposited on leaves out of water in June.

The dusky salamander has as its closest relative in the State, the Allegheny salamander, *D. o. ochrophaeus.* For a time I was convinced that the two should be regarded as only subspecifically distinct but further study of some supposed intergrades and a more complete knowledge of the life history and habits has convinced me that the species are distinct. The specimens which I had regarded

as intergrades proved on reexamination to be *D. o. ochrophaeus* which had lost and subsequently regenerated the tail, the regenerated portion in every instance being keeled above as in *D. f. fuscus*.

Range

New Brunswick to northern Florida, west to Mississippi, northward to Illinois.

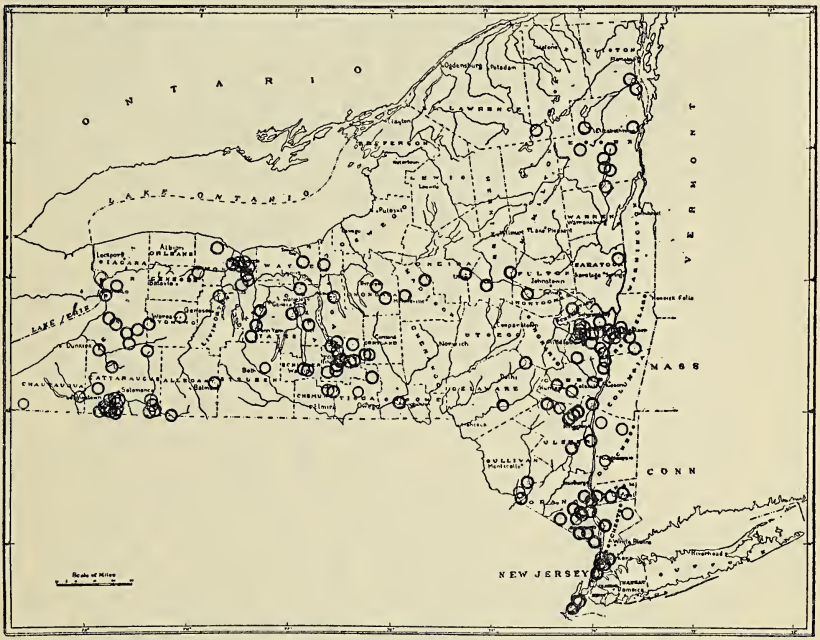

Fig. 62 New York localities for *Desmognathus fuscus fuscus*.

Distribution in New York

General. Throughout the State in suitable localities, including Long Island and Staten Island.

Specific records. ALBANY: *Albany* (Eights, 1835, Bishop, 1923); May 25, 1902, N. Y. S. M. No. 46 (F. C. Paulmier); June 6, 1902, 1 spec., N. Y. S. M. No. 50 (F. C. Paulmier); June 14, 1902, 2 spec., N. Y. S. M. (F. C. Paulmier); Oct. 26, 1902, N. Y. S. M. No. 46 (F. C. Paulmier); (Vrooman, 1909); *Altamont,* June 21, 1927, 3 spec. (Elizabeth, Edna, Arthur Were); *Clarksville,* May 8, 1926, 2 ads.; *East Berne* (Bishop, 1923); *Karner* (Bishop, 1923); *Kenwood* (Bishop, 1923); *Meadowdale,* Apr. 23, 1922, 2 spec., N. Y. S. M. (Bishop, 1923); *Medusa,* Apr. 13, 1922 (Bishop, 1923); between *New Salem* and *Indian Ladder Road,* Apr. 21, 1926, several seen (S. C. B. and W. J. S.); *Ravena,* May 3, 1924, 1 male, N. Y. S. M.; *South Bethlehem,* May 6, 1923, 4 spec. (H. P. Chrisp); *Thacher Park,* June 27, 1921, 1 male, N. Y. S. M. (Bishop, 1923); July 19, 1922, 1 male, N. Y. S. M. No. 9279; Aug. 27, 1925, 3 spec., N. Y. S. M. No. 1948–1950; *Feeney pond;* May 8, 1928, 1 ad.; *Indian Ladder,* June 14, 1921, N. Y. S. M. No. 9146 (Bishop, 1923); Oct. 4, 1924, 2 spec., N. Y. S. M.

(S. C. B. and W. J. S.); *Minelot creek,* June 21, 1927, 1 ad. (D. Cook); *Thompson's lake,* June 20, 1908, 2 spec., N. Y. S. M. (Bishop, 1923); *Voorheesville,* May 6, 1922, 2 spec., N. Y. S. M. No. 9179, June 4, 1922, 2 spec., N. Y. S. M.; June 10, 1922; July 26, 1922, 3♀ and eggs; Nov. 4, 1922, 5 spec., N. Y. S. M. No. 9371–75; Dec. 3, 1922, N. Y. S. M. No. 9444; Apr. 27, 1923, 1 spec.; Nov. 8, 1923, 1 spec., N. Y. S. M. No. 1457; Apr. 5, 1924, 5 spec., N. Y. S. M.; Mar. 26, 1925; May 18, 1925, 2 spec., Aug. 27, 1925; Apr. 13, 1926, many ads. and larvae (S. C. B., W. J. S. and H. H. Cleaves); Sept. 25, 1926, 10 ads. (S. C. B. and W. J. S.); Dec. 9, 1926, many (S. C. B. and W. J. S.); Apr. 16, 1927, 1 ad., U. R. No. 3274 (S. C. B. and B. S. Bronson); Apr. 30, 1927; July 29, 1927 (S. C. B. and T. I. Storer); Sept. 21, 1927, 1 ad.; Nov. 11, 1927, many ads.; Mar. 13, 1928, 3 ads., 1 larva (S. C. B. and W. J. S.); May 8, 1928, 3 larvae. ALLEGANY: *Alfred,* May 1934, ads. and larvae (F. W. Ross); *Ceres,* Bell's run, Aug. 30, 1926, 3 spec., N. Y. S. M. No. 3090–92. BRONX: *Van Courtlandt Park,* June 19, 1911, 1 spec., A. M. N. H. No. 2182; 1 spec., A. M. N. H. No. 1095 (Dunn, 1926); May 29, 1922, several spec., A. M. N. H. No. 16581–97 (L. Graf); *Woodlawn,* June 6, 1927 (P. Schiffer). BROOME: *Binghamton* (G. Bump). CATTARAUGUS: Feb., May, June, Oct., 1931 (Hassler, 1932); *Allegany State Park,* June 9, 1933, 1 yg. (S. C. B., H. Chrisp, K. Lagler and C. Zorsch); Oct. 19, 1934, many spec., U. R. No. 3440; Big basin, Aug. 5, 1927 (C. Coker); Blacksnake mountain, Aug. 20, 1926, many spec. (Bishop, 1927); July 1931, 1 ad. (H. Jack); Breed's run, Aug. 18, 1926, 2 ads., N. Y. S. M. No. 3158–59 (Bishop, 1927); Oct. 22, 1932, several ads. and larvae; Oct. 28, 1933, 2 spec., U. R. No. 3185; Oct. 20, 1934, many spec., U. R. No. 3441; Coon run, Aug. 3, 1922, 3 ads., N. Y. S. M. No. 3328 (Bishop, 1927); Frecks, Aug. 10, 1926, 3 ads., N. Y. S. M. No. 3173–75 (Bishop, 1927); Aug. 17, 1926, 5 ads., N. Y. S. M. No. 3170–72 (Bishop, 1927); Aug. 21, 1926, 1 ad., N. Y. S. M. No. 3209 (Bishop, 1927); Natural History School, Oct. 10, 1931, 2 spec., U. R. No. 2173–74; Aug. 27, 1937, sev. ads., U. R. No. 4200; May 7, 1938, sev. ads.; Quaker run, Aug. 1927, N. Y. S. M. No. 4091 (C. Markley); Ranger trail, Sept. 20, 1931, abundant; Oct. 29, 1933, 1 spec., U. R. No. 3275; Oct. 18, 1935, 2 ads., U. R. No. 4232 (M. H.); Oct. 15, 1938, many ads.; Upper Red House run, Aug. 25, 1926, 1 ad., N. Y. S. M. No. 3103 (Bishop, 1927); Red House valley, Aug. 13, 1926, 5 ads., N. Y. S. M. No. 3115–19 (Bishop, 1927); Seneca mountain, Aug. 30, 1921, 1 ad., N. Y. S. M. No. 3327 (Bishop, 1927); Stoddard creek, Aug. 17, 1922, 1 yg., R. Sta. 4447 (W. A. Dence); Willis run, Aug. 20, 1926, many (Bishop, 1927); Wolf run, Feb. 18, 1933, 1 larva, U. R. No. 3252; *Delevan,* Feb. 1–12, 1931, 30 spec. (N. M. Fuller); *East Randolf,* Feb. 19, 1931, 54 spec. (N. M. Fuller); *Gowanda,* Feb. 10, 1931, 4 spec., 60 larvae (N. M. Fuller); *Kenyon springs,* Feb. 4, 1931, 5 spec. (N. M. Fuller); *Kenyon summit,* E. Group, Feb. 4, 1931, 5 spec. (N. M. Fuller); *Otto,* Feb. 20, 1931, 114 spec. (N. M. Fuller); *Playfords spring area,* Feb. 13–20, 1931, 90 ads. and larvae (N. M. Fuller); Feb. 20, 1931, 10 spec. (N. M. Fuller); *Railroad springs,* Feb. 4, 1931, 30 spec. (N. M. Fuller); *Waterboro,* Oct. 24, 1937, 1 ad. CAYUGA: *Auburn,* 3 spec., C. U.; *Duck lake* (Wright and Moesel, 1919). CHAUTAUQUA: *Clymer,* Sept. 12, 1937, 1 ad. CHEMUNG: *Swartwood,* June 21, 1924, 1 spec. (S. C. B. and B. Bronson); *Van Etten,* Aug. 4, 1924, eggs, N. Y. S. M. (S. C. B. and W. J. S.). CLINTON: *Peru* (DeKay, 1842). CORTLAND: *Chicago bogs,* Oct. 10, 1933, 4 spec., U. R. No. 3184 (W. J. Koster); *Gracie,* May 2, 1934, 1 spec., U. R. No. 3404; *McLean bogs,* May 27, 1919, 4 spec., N. Y. S. M. DELAWARE: *Stamford,* June 25, 1922, 2 ads. and eggs, N. Y. S. M. No. 9248; 2 mi. E. of *Downsville,* June 29, 1935, sev. U. M. 78940 (Bailey); July 1, 1935, 6 spec. U. R. No. 3866. DUTCHESS: *Bangall,* Aug. 21, 1936, sev.; *Lagrangeville,* Aug. 20, 1936, sev.; *Lafayetteville,* July 5, 1938 (Van Auken). ERIE: *Buffalo,* 1925 (R. R. Humphrey); *Glenwood,* June 12, 1917, 1 spec. (J. W. Corrington); *Hamburg,* 6 spec., C. U.; *Holland,* 3 Valley Nature Reserve, Aug. 1–16, 1930, 21 spec., U. R. No. 2124 (E. L. Hilfiker); *North Boston,* Oct. 3, 1928, 2 ads., (F. J. Holl); *Springville,*

Williamsville, 1925 (R. R. Humphrey). ESSEX: *Adirondack Lodge,* Aug. 14, 1925, 1 spec. (F. Harper); *Blue Ridge,* June-Sept., 1926, A. M. N. H. (Weber, 1928); *Blue Ridge mountain,* Schroon Falls, June–Sept., 1926, A. M. N. H. (Weber, 1928); *Lake Champlain,* Camp Douglas, Aug. 19, 1902, N. Y. S. M. No. 58 (F. C. Paulmier); between *North Hudson* and *Underwood,* June–Sept., 1926, A. M. N. H. (Weber, 1928); *Paradox lake,* Severance, June–Sept., 1926, eggs, A. M. N. H. No. 21 (Weber, 1928); between *Tahawas* and *Lake Sanford,* June–Sept., 1926, A. M. N. H. (Weber, 1928); *Westport,* (Yarrow, 1882; Cope, 1899; Dunn, 1917); Aug. 22, 1923, (Green, 1923); 41 spec., U. S. N. M. No. 3915 (S. F. Baird). FRANKLIN: *Tupper lake,* M. C. Z. No. 4461 (T. Barbour). GENESEE *Bergen swamp,* Oct. 12, 1929, several spec., (S. C. B. and C. Bentley); Apr. 17, 1937, sev.; Apr. 29, 1937, sev. GREENE: *Coxsackie,* (5th Ann. Rept. State Cab. Nat. Hist., 1852); *Haines Falls,* A. N. S. (Fowler and Dunn, 1917); *New Baltimore,* Aug. 1893, 1 spec.; near *Schoharie creek,* Aug. 4–Sept. 14, 1896 (Mearns, 1899); 1 mi. N. E. of *S. Cairo,* June 19, 1936, sev.; *Urlton,* June 19, 1936, larvae (Bailey and Lagler). HERKIMER: 1895, C. M. No. 1673–75, 1666 (Ruedemann); *East Canada creek,* 1895, C. M. No. 1661–64 (Ruedemann); *Mohawk,* 1902 ads., A. M. N. H. No. 16830–6 (R. F. Call). LIVINGSTON: *Avon,* Apr. 13, 1929, ads. and yg. (W. Pierson); Apr. 27, 1929, several spec. (W. Pierson). MADISON: *Cazenovia,* Aug. 1908, 1 spec. (I. J. Vrooman); *Kenwood,* 1891–92, 5 spec. (Marshall, 1893). MONROE: (Wright and Moesel, 1919); *Allen's creek,* Apr. 11, 1929 (S. C. B. and R. Hart); *Bushnell basin,* Feb. 19, 1930, 18 spec. and eggs, U. R. No. 773 (S. C. B., H. Lauterbach and P. Mathias); Nov. 21, 1930, 2 spec., U. R. No. 2192 (P. R. Needham); Feb. 5, 1931, many spec.; Feb. 20, 1931, 33 ads., 82 juv. (S. C. B. and R. Hart); Nov. 20, 1931, 2 ads., 2 larvae; Feb. 8, 1932, many ads. and yg. (T. Forbes and K. Lagler); Dec. 2, 1932, 25 spec., U. R. No. 2815, 2816; Jan. 20, 1933, 3 spec., U. R. No. 3109, 3182; Jan. 24, 1933, 2 ads.; Mar. 13, 1934, 74 ads., 1 juv., U. R. No. 3401 (C. P. Zorsch); Apr. 3, 1934, 30 ads., 6 juv., U. R. No. 3402 (C. P. Zorsch); May 11, 1934, many spec., U. R. No. 3403 (C. P. Zorsch); Nov. 6, 1936, many; Nov. 4, 1937, ads.; Feb. 28, 1937, ads.; *Corbett's glen,* Mar. 17, 1933, 39 ads., 8 juv., U. R. No. 3108 (S. C. B. and H. Chrisp); Mar. 18, 1933, 7 ads. and juv., U. R. No. 3186 (S. C. B., H. Chrisp and C. Bentley); Apr. 9, 1933, 1 spec., U. R. No. 3188; Oct. 6, 1933, 15 ads., 1 juv., U. R. No. 3187; Mar. 24, 1934, 44 ads., U. R. No. 3400 (C. P. Zorsch); Apr. 4, 1934, 1 ad., 2 larvae, U. R. No. 3406 (C. P. Zorsch); Nov. 4, 1937, many ads.; *Hilton* (Wright and Moesel, 1919); *Mendon* (Wright and Moesel, 1919); *Penfield Dugway swamp,* Apr. 3, 1934, 5 spec. (R. G. Redman); *Powder Mill Park,* (Wright and Moesel, 1919); Apr. 8, 1937, sev.; Mar. 21, 1938, sev. U. S. No. 4448; *Rochester,* Palmer's glen, Feb. 19, 1930, several (S. C. B., H. Lauterbach and P. Mathias); Maplewood Park, Oct. 4, 1928, several ads.; May 15, 1933, 1 spec., U. R. No. 3106 (F. J. Clark); *Tufa glen,* June 29, 1929, many; Nov. 16, 1931, 1 ad., U. R. No. 2151–52; Mar. 12, 1933, many spec., U. R. No. 3107 (S. C. B. and H. Chrisp); Oct. 1, 1933, 3 spec., U. R. No. 3183, 3266. MONTGOMERY: *Nelliston,* Nov. 18, 1920, N. Y. S. M. NEW YORK: *Harlem* (Rafinesque, 1820). ONEIDA: 2, Royal Ontario Mus. (Dunn, 1926); *Utica,* 1886, M. C. Z. No. 4462-66 (Dunn, 1926). ONONDAGA: *Onondaga Valley* (Britcher, 1903); *Hopper's glen* (Slater, mms); *Pompey Hill* (Britcher, 1903). ONTARIO: *Canandaigua lake,* Mentieth glen, Sept. 22, 1928, 3 spec., U. R. No. 3277 (E. A. Maynard); *Woodville,* Aug. 1929, several; Sept. 1, 1932, 1 ad.; July 13, 1935, 1 ad.; *Kashond creek,* May 20, 1932, Hobart College (T. T. Odell); *Naples,* Aug. 21, 1923, 2 spec., N. Y. S. M. No. 9530. ORANGE: 1 spec. (Dunn, 1917); *Greenwood Lakes glen,* Brooklyn Mus. No. 746 (Dunn, 1926); 1 mi. South of *Harriman,* Apr. 12, 1930 (Burt, 1931); *Highland Falls,* 16 spec., U. S. N. M. No. 23222–37, 23293 (E. A. Mearns); *Mountainville,* June 13, 1920, ads., A. M. N. H. No. 12866–12868–73 (G. K. Noble and C. L. Camp); *Palisades Interstate Park,* Bear Mountain section, Summer 1923, all sizes, A. M. N. H. No.

24183–206 (G. S. Myers); Kanohwahke lakes, July–Aug. 1923, common (Myers, 1930); 1 mi. north of Lake Tiorati, Apr. 12, 1930 (Burt, 1931); Tiorati brook, Aug. 11, 1923, ads., A. M. N. H. No. 24218–21 (G. S. Myers); 4 mi. N. E. of *Port Jervis,* June 23, 1935, 5 ads. U. M. No. 78858 (Bailey); *Sutherland pond,* Sept. 2, 1910, 1 spec., U. S. N. M. No. 42788 (E. A. Mearns); *West Point,* 2, M. C. Z. No. 5648, Brooklyn Mus. No. 1252 (Dunn, 1926). PUTNAM: *Carmel,* May 23, 1926, 3 spec. (S. C. B., H. Hasbrouck and H. H. Cleaves); *Garrison,* Aug. 9, 1883; A. M. N. H. No. 2231–42 (Zenga); 12 spec., A. M. N. H. No. 447 (Dunn, 1926); 28 mi. N. E. of *Mahopac,* July 24, 1936, ♀ with eggs; *Tompkin's Corners,* July 5, 1922, 1 spec., N. Y. S. M. (A. Wolf). RENSSELAER: *Averill Park,* June 17, 1902, 3 spec., N. Y. S. M. (F. C. Paulmier); *Defreestville,* Oct. 22, 1920, 1 spec. (W. J. S.); *East Greenbush,* June 9, 1902, N. Y. S. M. No. 51 (F. C. Paulmier); *East Nassau,* June 22, 1922, N. Y. S. M. (S. C. B. and A. Wolf); *Mill creek,* May 1, 1902, N. Y. S. M. No. 61 (F. C. Paulmier); *Rensselaer,* June 24, 1902 (F. C. Paulmier); May 1926, 1 spec. and eggs, N. Y. S. M. No. 4044 (J. Heller). RICHMOND: *Staten Island* (Davis, 1884; Dunn, 1917; Wilmott, 1933); various sized specimens, A. M. N. H. No. 467, 2176–78, 2246–69 (N. Pike). ROCKLAND: Apr. 4–10, 1909, 2 spec., N. Y. S. M. (E. J. Cline); *Dunderburg mountain,* Apr. 12, 1930 (Burt, 1931); *Monsey,* July 1894, A. M. N. H. No. 3650–57; *Orangeburg,* June 7, 1923, ads. and yg. A. M. N. H. No. 18794–7, 18799–800 (G. K. Noble and G. S. Myers); *Suffern,* May 26, 1924, 1 spec., N. Y. S. M. No. 1515. SARATOGA: *Fortsville,* July 8, 1932, 1 ad. SCHENECTADY: near *Mariaville,* May 5, 1923. SCHUYLER: *Aunt Sarah's falls,* Sept. 20, 1932, abundant (J. A. Weber); *Montour Falls,* May 20, 1933, 4 spec., U. R. No. 3012; *Watkins glen,* June 10, 1935, 1 ad. U. M. No. 78859 (Bailey). SENECA: *Junius* (Wright and Moesel, 1919); *Ovid,* 1855, M. C. Z. No. 1158 (W. H. Brewer); (Dunn, 1918). STEUBEN: *Cold Spring* near Bath, June 30, 1937, abdt. SULLIVAN: *Oakland valley,* 1922, 1 yg., A. M. N. H. No. 14909 (J. A. Weber). TIOGA: *Berkshire,* M. C. Z. No. 196, 458–90, 1157, 1161(3), 174, 231, 156 (A. Mayor); *Candor,* Aug. 26, 1935, 2 ads. TOMPKINS: *Cayuga lake,* Willow point, Sept. 11, 1919, 1 spec. (J. D. Corrington); *Coy glen,* Apr. 10, 1910, C. U.; Mar. 27, 1920, C. U.; *Groton,* June 3, 1917, 2 spec. (J. D. Corrington); July 7, 1918, 3 spec. (J. D. Corrington); June 7, 1919, 3 spec. (J. D. Corrington); *Ithaca,* June or July 30, 1901; June 1904, M. C. Z. No. 4467–8, 4991 (R. V. Chamberlin); Mar. 7, 1908, C. U.; Apr. 13, 1909, 2 spec., U. S. N. M. No. 39409–10 (Allen and Wright); 21 spec. (Dunn, 1917); Bool's backwater, Apr. 2, 1913, C. U.; Mar. 26, 1914, C. U.; Feb. 6, 1915, C. U.; Feb. 14, 1917, C. U.; Cascadilla valley, July 28, 1919, 1 spec. (J. D. Corrington); *Glenside,* Apr. 5, 1919, C. U.; *Larch Meadows* (A. H. Wright); *Ludlowville,* Spring of 1924 (C. A. Arnold); *McLean bogs,* 1922–1925, ads. and larvae (Leffingwell, 1926); May 2, 1934, 1 spec., U. R. No. 3405; *Newfield,* Mar. 7, 1921, C. U.; *Renwick,* Apr. 19, 1917, 2 spec. (J. D. Corrington); Mar. 17, 1923, C. U.; *Ringwood,* Aug. 8, 1923 (S. C. B. and A. H. W.); *Taughannock creek,* Oct. 1, 1922, C. U. (R. R. H.); *Turkey hill,* Mar. 6, 1921, C. U. (R. R. H.); Mar. 15, 1922, C. U.; Aug. 8, 1923, 1 spec., N. Y. S. M. No. 9526 (S. C. B. and A. H. W.). ULSTER: *Ashokan,* Aug. 5, 1909, 1 ad., A. M. N. H. No. 2229 (A. L. Treadwell); Aug. 19, 1909, ads. and yg., A. M. N. H. No. 2226–8 (A. L. Treadwell); Aug. 25, 1909, 2 ads., A. M. N. H. No. 2224–5 (A. L. Treadwell); *Big Indian,* Sept. 1918 (Wm. T. Davis); *Lake Mohonk,* Aug. 26, 1927 (J. A. Weber); 1 mi. W. of *Phoenicia,* June 13, 1936 (Hall and Stone); *Samsonville,* June 17, 1936 (Bailey and Lagler); *Saugerties,* Aug. 23, 1911, ads. and yg., A. M. N. H. No. 1425–30 (G. von Krockow); *Shokan,* 8 spec., A. M. N. H. No. 425, 427–8, 464 (Dunn, 1917); *West Park,* Nov. 25, 1917, 2 ads., A. M. N. H. No. 5421–2 (Fisher, 1918); *Woodstock,* 1918, 8 spec., U. S. N. M. No. 61110–2, 61113–14, 61115–9 (E. Uhlenhuth). WARREN: *Adirondack* (Cope, 1869; Cope, 1889); (Dunn, 1917); 1 spec., U. S. N. M. No. 3912 (R. Clarke). WAYNE: (Wright and Moesel, 1919); *North Rose,* Sept. 1911, 1 spec., U. S. N. M. No. 48546 (A. C. Weed). WESTCHESTER: (Deckert, 1914); 2½ mi. E. of *Cross River,* July 15, 1936

(Bailey and Lagler); *Mount Vernon,* Nov. 30, 1906, A. M. N. H. No. 2184–5; *Ossining,* July–Aug. 1923 (Myers, 1930); *Yonkers,* Apr. 20, 1919, 2 ads., A. M. N. H. No. 6395–6 (G. K. Noble and K. P. Schmidt); Mar. 31, 1928, 1 spec. (W. G. Hassler); Nov. 8, 1928, 1 spec. (W. G. Hassler) (Noble and Weber, 1929). WYOMING: *Strykersville,* Oct. 7, 1928, 3 spec. (F. J. Holl).

Records too indefinite to be placed in counties. *New York,* may be presumed to inhabit this State (DeKay, 1842); (Boulenger, 1882); May 8, 1883, 1 ad., A. M. N. H. No. 2715 (E. A. Mearns); abundant in the vicinity of small streams (Ditmars, 1905); 3 spec. (61st Ann. Rep't N. Y. S. M., 1908); *Catskills,* 29 spec., U. S. N. M. No. 23181–209 (E. A. Mearns); *Cayuga Lake basin,* abundant (Reed and Wright); 1925–1932 (Hamilton, 1932); *Hudson Highlands,* common (Mearns, 1898); *Long Island,* 1878–89, ads., A. M. N. H. No. 2755–69 (N. Pike); 1884, larvae and ads., A. M. N. H. No. 2061–82, 2084–85, 2140 (N. Pike); 43 spec., A. M. N. H. No. 894–8, 900–15, 917–18 (Dunn, 1926); *Northern New York* (Baird, 1850); (Dunn, 1917); (Rafinesque, 1820).

Condensed Bibliography

Life history and habits. Bishop, 1927, p. 56 (*Desmognathus fuscus fuscus*); Cope, 1889, p. 196 (*D. fusca fusca*); Ditmars, 1905, p. 178 (*D. fusca*); Dunn, 1917, p. 410 (*D. fusca fusca*); Dunn, 1926, p. 88 (*D. fuscus fuscus*); Hamilton, 1932, p. 86; Hilton, 1904, p. 498 (*D. fusca*); Hilton, 1909, p. 533; Kingsbury, 1902, p. 99; Leffingwell, 1926, p. 72 (*Desmognathus fuscus fuscus*); Noble and Brady, 1930, p. 53 (*D. fuscus fuscus*); Noble and Evans, 1932, p. 1–16; Noble and Weber, 1929, p. 1–15; Surface, 1913, p. 104 (*D. fusca*); Unterstein, 1929, p. 245 (*D. fuscus*); Wilder, H. H., 1899, p. 231; Wilder, H. H., 1904, p. 117 (*D. fusca*); Wilder, I. W., 1913, p. 251–342; Wilder, I. W., 1917, p. 13; Wilder, I. W., 1923, p. 88.

Distribution in New York. Baird, 1850, p. 285 (*Desmognathus fuscus*); Baird, 1852, p. 21; Bishop, 1923, p. 67 (*D. fuscus fuscus*); Bishop, 1925, p. 11 (*D. fuscus*); Bishop, 1927, p. 56 (*D. f. fuscus*); Boulenger, 1882, p. 78 (*D. fuscus*); Britcher, 1903, p. 21; Burt, 1931, p. 200 (*D. f. fuscus*); Cope, 1869, p. 115 (*D. fuscus*); Cope, 1889, p. 194 (*D. fusca fusca*); Davis, 1884; Deckert, 1914 (*D. fusca*); Ditmars, 1905, p. 178 (*D. fusca*); Dunn, 1917*a*, p. 412 (*D. fuscus*); Dunn, 1918, p. 463 (*D. fusca fusca*); Eckel and Paulmier, 1902, p. 402 (*D. fusca*); Eights, 1835, p. 130 (*Salamandra nigra*); Fisher, 1918, p. 65 (*Desmognathus fuscus*); Fowler and Dunn, 1917, p. 22 (*D. fusca*); Green, 1923, p. 99 (*D. fuscus fuscus*); Hamilton, 1932, p. 86; Hassler, 1932*a*, p. 303, 310; Mearns, 1898, p. 324 (*D. fusca*), Mearns, 1898*a*, p. 345 (*D. fuscus*); Myers, 1930, p. 101 (*D. f. fuscus*); Noble, 1927, p. 3; Noble and Weber, 1929, p. 3; Rafinesque, 1820, p. 4 (*Triturus fuscus, T. nebulosus*); Reed and Wright, 1909, p. 404 (*D. fusca*); Sherwood, 1895, p. 33; Weber, 1928, p. 107 (*D. fuscus fuscus*); Wilmott, 1933, p. 164; Wright and Moesel, 1919, p. 64; Yarrow, 1882, p. 159 (*D. fusca fusca*); 46th Ann. Rep't N. Y. State Mus. 1893, p. 22 (*D. fusca*); 61st Ann. Rep't N. Y. State Mus. 1908, p. 132 (*D. fuscus*); 62d Ann. Rep't N. Y. State Mus. 1909, p. 100 (*D. fusca*).

DESMOGNATHUS OCHROPHAEUS OCHROPHAEUS (Cope)

(*Desmognathus ochrophaea,* Proc. Acad. Nat. Sci. Phila., 1859, p. 124)

Allegheny Salamander, Mountain Salamander

Figures 3*j–k*, 63–64*e–g*, 65–66

Of all the salamanders in the State, this is the most variable in color and at the same time one of the most constant in the pattern of its markings.

Description

Size. The average length of 40 mature males collected in the vicinity of Rochester, N. Y., is 70.33 mm, with extremes of 53 and 96 mm. Forty mature females taken at the same time average 72.95 mm and the extremes are 46 and 88 mm. It is apparent, in this locality at least, that while individual males may exceed in length the longest females, they average somewhat smaller.

Dunn (1926, p. 117) gave 90 mm as the length of the longest male in a series collected at Gold, Potter county, Pa., and 87 mm as the longest female.

Form. This is a slender species with a well-rounded trunk and slim, tapering tail. The skin is smooth and shining with only a few large pores but everywhere very finely pitted.

The head is flattened above, narrow, oval in outline, widest at the angle of the jaws and converging to the bluntly rounded and depressed snout. The eye is comparatively small, its horizontal diameter contained almost twice in the snout. On the side of the head, on a line between the lower edge of the eye and nostril, is a series of two or three fairly large pores. The gular fold is well developed and continues on the sides of the neck where it joins a vertical groove extending to the back and an arched impressed line extending forward to the eye. A short vertical groove from the angle of the jaw joins the arched line a short distance back of the eye. The commissure of the mouth in the male is strongly sinuous.

There are 14 costal grooves, counting one each in the axilla and groin. The grooves are continued across the upper sides and in some individuals they bend sharply forward and meet the median impressed line which extends from the back of the head to a point opposite the posterior end of the vent.

The belly is somewhat flattened and usually there is evident a slightly impressed median line.

The fore legs are rather short and slender with the toes short, stubby and webbed at base, in order of length, 1-4-2-3. The hind legs are stouter and longer than the fore, webbed at base, the toes in order of length 1-5-2-4-3. There are 3½ to 4 costal folds between the appressed toes.

The tail is slender, without keels, nearly round in cross section at the base and gradually tapering to the slender tip. Occasionally a specimen will be found in which the tail is keeled above but if carefully examined it is usually evident that the keeled portion is limited to a section that has been regenerated.

Fig. 63 *Desmognathus ochrophaeus ochrophaeus.* Adult female, actual length 70 mm, Corbett's glen, Rochester, N. Y., Mar. 17, 1933. b. Adult male, ventral view, actual length 90 mm, Tufa glen, Monroe Co., N. Y., Mar. 12, 1933. H. P. C., del.

The teeth of adult males are irregularly developed on the mandible and extend back to a point opposite the anterior corner of the eye, the hindmost somewhat enlarged. The premaxillary teeth are enlarged, flattened, recurved at tip and directed forward where they lie against the upper lip. The maxillary is partly edentulous, the teeth small and blunt. The vomerine teeth are lacking in the adult males. Parasphenoid teeth are in two long, club-shaped patches, well separated and extending forward to a point opposite the posterior corner of the eye. In the female, the maxillary, premaxillary and mandibular teeth are small, evenly distributed and none are conspicuously enlarged. The vomerine teeth, four to six on each side, are in short, slightly curved series which begin opposite the inner edge of the nares. The patches are separated by about the length of one series and a little farther from the parasphenoids. Parasphenoid teeth in two long, slender divergent patches, nearly or actually in contact anteriorly.

The tongue is moderately broad, attached at the middle line in front and with the sides and posterior third free. The surface lacks conspicuous folds but is very finely clothed with villi.

Color. The general pattern is very constant in this species but the colors are extremely variable. There is a broad, dorsal light band with straight edges below which the sides of the trunk and tail are dark, almost black. The lower sides are generally mottled and fade into the belly which is generally more or less pigmented but unmottled. On each side of the head from the eye to the angle of the jaw, there is a short, light bar.

In old individuals the light dorsal band may become almost obliterated so that the pattern is difficult to make out but the great majority of specimens will have a pattern as indicated above.

The dorsal stripe originates on the head, sometimes at the snout but usually on the upper surface just behind the eyes, and continues along the trunk and tail almost to the tip. The color of the band varies from light tan or pale yellow through various shades of red, gray and brown to almost black. Within the band there are usually scattered dark spots variable in size and number but generally small and often forming a single, more or less regular, median line. The upper sides are darkest next to the band and in very light colored individuals, the dark pigment is concentrated in a fairly narrow stripe; in others, the dark of the sides gradually fades into the mottled lower sides. The belly and lower surface of the tail are quite uniformly colored and generally darker than in *Desmognathus*

f. fuscus. The throat and lower surface of the limbs is flesh-colored, the belly and tail with shades of bluish or lavender.

Individuals with a very light dorsal band are sometimes confused with *Eurycea b. bislineata* but the compressed tail and yellow under parts of the latter should immediately distinguish it. Occasionally a specimen will be found that has a striking superficial resemblance to some color phase of *Plethodon cinereus* but the different bodily proportions, the comparatively larger hind legs and the light bar from the eyes to the angle of the jaw in *D. o. ochrophaeus* will serve as recognition characters.

Sexual differences. The most easily recognized character by which the sexes may be separated is the shape of the lower jaw when viewed from below. In the male, the tip of the lower jaw is obliquely truncated and produced forward into a blunt lobe. This is apparently a glandular area although not so well differentiated as in *Desmognathus f. fuscus.* The commissure of the laws in the male is strongly sinuous, that of the female only moderately so. In the specimens I have measured from the vicinity of Rochester, the females average a little longer than the males in total length but a little shorter in body length. In adult males the vomerine teeth are lacking, the teeth on the mandible are irregular and enlarged posteriorly and the premaxillary teeth are enlarged. Parasphenoid teeth in the males are in two separate patches.

Activities of the Breeding Season

Mating. There is, apparently, an extensive season and mating takes place both in the fall and spring. Whether or not it continues through the summer remains to be determined.

On October 1, 1933, many adults were collected from beneath stones in a drying creek bed near Rochester, N. Y., and confined together in leaf-filled jars. On the morning of October 2d some females were found with portions of spermatophores held in the vent. The specimens were then paired off in jars and on the following morning complete spermatophores were found attached to leaves and the bottom of the jars and one female had recovered the sperm mass from a spermatophore and held it in the lips of the cloaca.

Some mature females at this time contained large eggs, one dissected having six in the right ovary and nine in the left, averaging 2.26 mm in diameter. Other females had apparently deposited the season's complement for the ovarian eggs were small. On the same date, October 1st, a cluster of eggs at the point of hatching was

found beneath a flat stone. Eight of the eggs formed a compact mass attached to the lower surface of the stone and three single ones were on the ground, possibly detached accidently. The eggs were attended by a small individual which on dissection proved to be a spent female.

It has already been shown (Bishop and Chrisp, 1933, p. 198) that spermatophores are sometimes deposited in the spring for, on May 12, 1933, a female collected near West Webster, N. Y., was found holding the sperm cap of a spermatophore in the vent. At this season, May, females are often found with 3 mm ovarian eggs.

Spermatophores. The spermatophore of this species is a small stump-shaped structure having a clear gelatinous base and a whitish sperm cap. The basal part is only slightly flanged and has a diameter of about 2½ mm. The height of the complete spermatophore is approximately 2 mm. The whitish sperm cap in the specimens examined, did not have the stratified appearance characteristic of the freshly deposited spermatophore of *D. f. fuscus.*

The egg-laying process. We have not witnessed the actual deposition of the eggs but from their disposition it is apparent that in this species, as in many others, the female turns herself upside down while fastening her eggs to the supporting object.

The egg mass. Typically, the eggs of this species are deposited in a cluster, the outermost envelop of the individual eggs being drawn out and attached to a common stalk so that the mass has the appearance of a small bunch of grapes. The mass as a whole is attached to the lower surface of the object that serves as the cover of the nest or retreat.

The eggs do not invariably form a single cluster as we have already shown (Bishop and Chrisp, 1933, p. 198). Occasionally part of the complement will be deposited in a compact group and the remainder in pairs or singly. Weber (*ibid.*, p. 198) found one cluster containing six eggs and the remainder of the complement, six eggs, deposited singly. Another lot consisting of a total of 12 eggs was deposited in sets of three pairs and six single eggs. A single clutch of 12 eggs was found.

As in the case of *Plethodon cinereus,* a few eggs are sometimes found unattached.

The eggs comprising the complement of a single female vary in number from 11 to 14. We have found a single lot containing 11 eggs, three lots containing 12 and three 14.

Individual eggs in the clusters are frequently elongate and have a bulbous protuberance at the free end.

Development

The egg and its envelops. Individual eggs well advanced in development have a diameter of approximately 4 mm, the size depending somewhat on the amount of moisture present in the environment. It has been impossible to determine, with any degree of accuracy, the disposition of the individual envelops or even their number. Only a single lot of freshly deposited eggs has been found and these were too poorly preserved to permit an accurate description.

The incubation period. The length of the period of incubation has not been determined. Fresh eggs were found August 2, 1924, (Bishop, 1925, p. 11) and eggs at the point of hatching and recently hatched young on the dates given below:

LOCALITY	DATE	NUMBER OF EGGS	STAGE
Woodcock Creek, Pa.....	Sept. 26, 1932	12 (3 lots)	Ready to hatch
Rochester, N. Y.....	Mar. 12, 1933	14	Recently hatched
Rochester, N. Y.....	Mar. 17, 1933	several	Recently hatched
Rochester, N. Y.....	Mar. 18, 1933	14	Recently hatched
Rochester, N. Y.....	Oct. 1, 1933	11	Ready to hatch
Letchworth Park.....	Oct. 7, 1933	14	Recently hatched

The newly hatched larva. The average length of ten specimens is 17.85 mm. The body is well developed and well proportioned. The head is broadest at the eyes, converges slightly to the broadly rounded snout and continues behind to the gills with the sides nearly parallel. Just behind the gills the head narrows abruptly. The pupil of the eye is oval and black, the iris black with flecks of gold. The gills are short, slender filaments with sometimes one or two very short branches; their length about equals the longest toe of the front foot. The 14 costal grooves are lightly but clearly developed; the gular fold is prominent. The tail is oval in cross section at the base but at a point about one-third the length from the vent it becomes compressed and develops a slight, low keel which is most prominent on the distal third.

The general ground-color of the sides, the legs and the venter are dull white; that of the back is dull yellow tinged with pinkish. The snout above is mottled with pigmented areas and small light spots. From the eyes a median light area is continued backward, abruptly widening behind the eyes to nearly the full width of the head. Just above the gills it contracts and continues along the midline of the

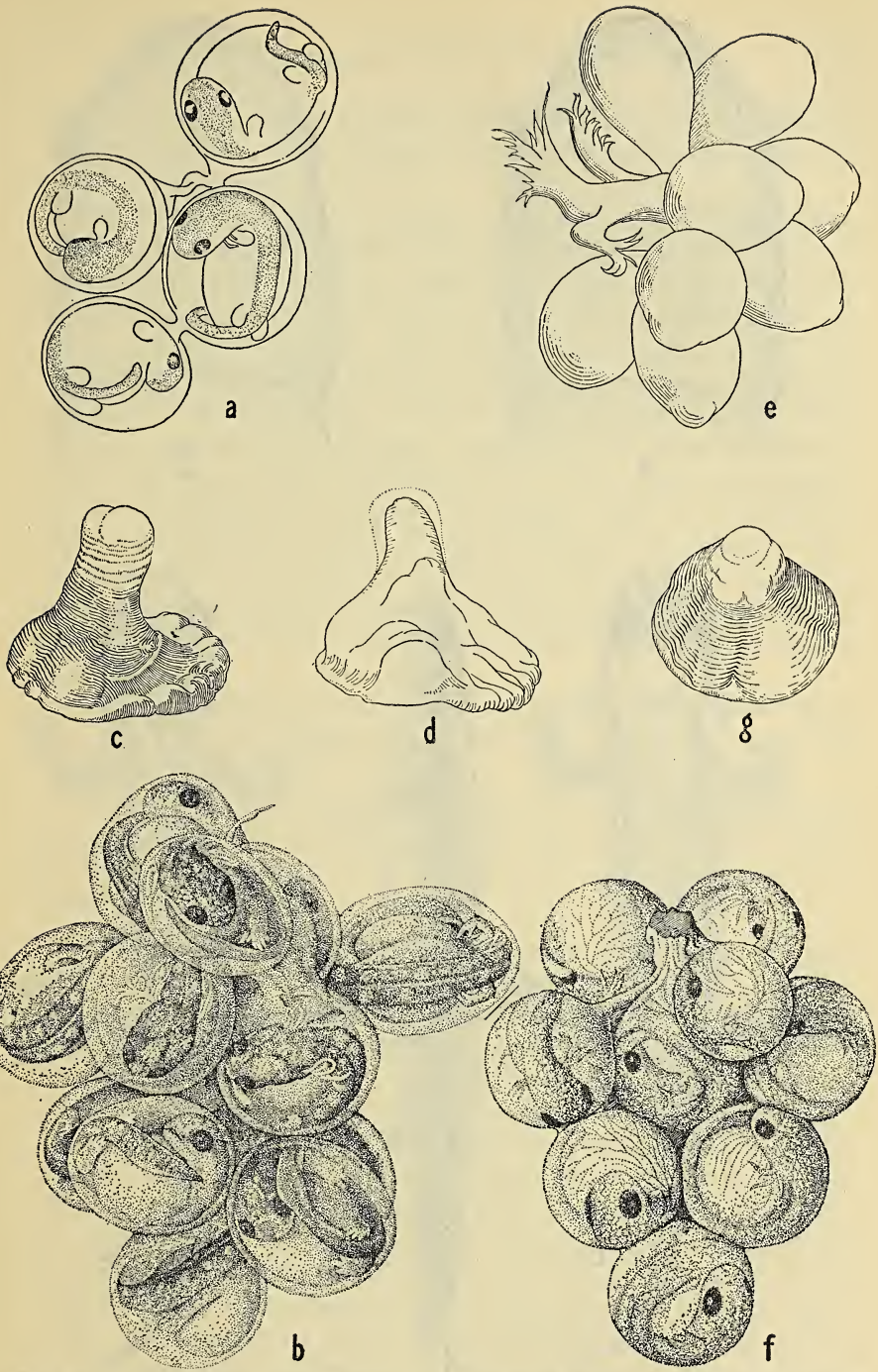

Fig. 64 *Desmognathus fuscus fuscus*. a. Encapsuled embryos to show manner of attachment of envelops. Voorheesville, N. Y., July 26, 1922. W. J. S., del. b. Egg-mass with well-developed embryos, Conneaut lake, Pa., Aug. 25, 1925. H. E. R., del. c. Spermatophore, Rochester, N. Y., Mar. 19, 1933. Note flangelike base and laminated structure of sperm cap. H. P. C., del. d. Spermatophore with cap removed by cloaca of female. Outline of cap indicated by dotted line. e. *Desmognathus ochrophaeus ochrophaeus*. Empty egg-capsules, Corbett's Glen, Rochester, N. Y., Mar. 18, 1922. H. P. C., del. f. Egg-mass, Tufa Glen, Rochester, N. Y., Oct. 1, 1933. Note grapelike cluster and stalk by which eggs were attached. H. E. R., del. g. Spermatophore, Rochester, N. Y., Oct. 1, 1933.

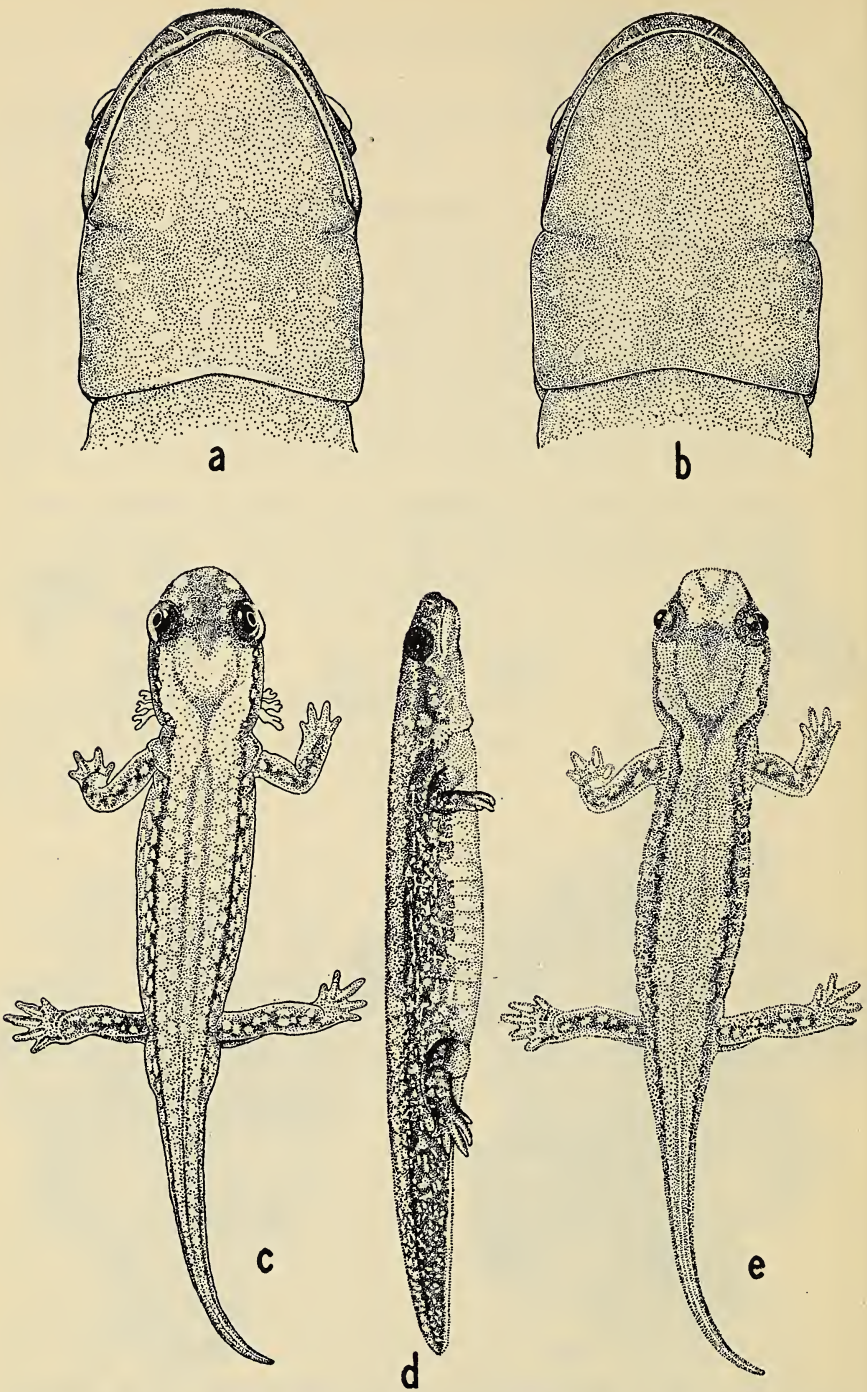

Fig. 65 *Desmognathus ochrophaeus ochrophaeus.* a. Under side of head of adult male to show the contour of jaw and glandular area at tip. H. M. Z., del. b. Under side of head of female. H. M. Z., del. c. Larva at hatching, Tufa Glen, Rochester, N. Y., Mar. 12, 1933. Actual length, 17 mm. H. P. C., del. d. Side view of larva showing the low tail keel and reduced gills, March 18, 1933. H. E. R., del. e. Just transformed, Mar. 26, 1933. Note the light snout which is characteristic of the recently transformed individual. H. P. C., del.

trunk as a broad band with nearly straight edges. This band begins to taper at the base of the tail and continues along the middorsal line of the tail to its tip.

The dorsal light band is flecked with scattered chromatophores slightly concentrated to form a Y-shaped mark on the head between the gills and an irregular spot between the eyes. The dorsal band is limited each side by a broad dark band which originates on the snout in front of the eye, passes through and below the eye and continues on the side of the head and along the side of the trunk and tail. This lateral band is darkest along its upper margin where the chromatophores are strongly concentrated in a rather narrow stripe next to the light median band; the lower sides are strongly mottled with pigment-free areas of irregular shape and variable in size. The legs and feet are strongly suffused with grayish. The ventral surface of the head, tail and legs is dull white with only a few scattered chromatophores along the margin of the lower jaw and on the tail near its tip. The belly is bright yellow, colored by the yolk.

The unpigmented areas of the back receive their dull yellow from the yolk and the pinkish tinge from the superficial veins and capillaries.

The most striking feature of the larva is the broad, light, dorsal band which is entirely lacking in the paired, dark-bordered spots characteristic of larval *D. f. fuscus* and to some extent of larval *D. o. carolinensis.*

Length of the larval period. The length of the period the gills are retained is apparently determined largely by the amount of moisture present and, to some extent, by the temperature. Larvae taken March 12th had well developed but short gills free from pigment. On March 16th the gills on some individuals had shortened to half their length. They remained in this condition through March 20th. On March 24th all but one of ten specimens kept alive had reduced the gills about one-half. March 28th, nine of the ten specimens still retained very short gill rudiments, one had lost the gills entirely. On April 1st all but one had lost the gills, the single individual retaining short rudiments until April 7th. This lot of specimens was kept among saturated leaves in a glass jar under cold running water.

The larvae collected March 18th were kept among damp leaves at room temperature of 68°–70°F. On March 24th, nine of the ten specimens kept alive had lost the gills entirely and had undergone a remarkable color change. The single specimen which retained short gills also retained its larval pattern.

It is evident, therefore, that the gills may be lost within a few days after hatching or retained several weeks.

Transformation. The average length at transformation is 18 mm. The superficial black chromatophores on the snout which gave a mottled pattern in the larva, largely disappear at transformation leaving the snout conspicuously light. The mottling of the sides is also lost in the generally darker color of the sides below the dorsal band. On a few individuals there is a very slight development of large, round, paired, light spots.

Development to maturity. In attempting to determine the rate growth and the size and age at the attainment of sexual maturity, 205 adults and juveniles from Rochester, N. Y., collected during October, November, March and April have been measured and dissected.

As shown above, eggs may hatch either in the fall or early spring but since there is very little growth during the winter months, measurements of specimens taken at these seasons should be fairly reliable.

In plotting growth curves, body length only has been taken for the adults but for the juveniles both body and total lengths have been considered.

As indicated above, the young transform at an average length of 18 mm. In addition to these individuals, other juveniles may be found (both in spring and fall) that vary from 26 to 50 mm in total length. When the individuals composing this group are measured and the figures plotted in the form of a graph with 2 mm class intervals, a rather definite mode is found at 30 mm and one less pronounced at about 42 mm. When body length only is taken, the extremes are 16 and 29 mm and the modes fall at 18 and 25 mm.

In body length, adult males vary from 28 to 46 mm and adult females from 26 to 42 mm. When plotted the graphs show a prominent mode at 29 mm and one at 32 mm, the lower figures representing the males and the higher one the females. Another prominent mode is evident at 36 mm, again representing the males, and one at 40 mm, the females.

I interpret these figures as follows: a body length of 18 mm is attained at the end of the first year or in the case of individuals hatched in the fall, in about 18 months. Sexual maturity may be attained in the fall of the year following (or six months later, in the spring) when males have attained a body length of 29 mm and

the females 32 mm. The body lengths of 36 and 40 mm represent the growth of the males and females during the third and subsequent years. In other words, sexual maturity is usually attained at the end of the second year or at the beginning of the third season.

Habits

General. Like the majority of our salamanders, this species is seldom observed in the open except at night when it may sometimes be found foraging in the vicinity of the retreats that have sheltered it during the day.

It is extremely active when disturbed and makes its way by running and by violent lateral contortions involving the body and tail.

The species is terrestrial, particularly during the warmer months when it may often be found a considerable distance from water. At the approach of colder weather, it seeks the springs, streams and boggy areas where it hides, not actually in the water, but beneath stones, old logs or moss and leaves where the ground beneath is saturated.

Food. Nothing has been published on the food of this species. Twenty specimens, eight of which contained food, have been examined. Insects comprised the most important item both in bulk and in number of species. The following were recognized: ants, tipulid adult, dipterous larvae, lepidopterous larvae, aphid, and fragments of undetermined homopterous and hymenopterous insects; spiders, mite, phalangid, millipede; shed skin, plant fragments and sand.

Habitat

In localities where the species is common, it should be found under logs, bark and stones both in the vicinity of streams and springs and on hillsides some distance from water. When attending her eggs, the female will invariably be found in the vicinity of springs, boggy areas or streams where, during the period of incubation at least, the soil or rocks are constantly moist. During periods of drouth, as in the fall of 1933, the nest site may become nearly dry but the female remains with her young after they hatch and the entire group may sometimes be found in a compact mass, their bodies in contact with one another.

During the winter months these salamanders sometimes congregate in great numbers in the crevices of shale banks bordering woodland streams or beneath the loose pieces of rock, stranded logs, or bark that lie in the shrunken stream beds.

In New York State, the Allegheny salamander is frequently found with the dusky salamander, *Desmognathus f. fuscus.* This is particularly true during the fall and winter when both species often share the same shelter. During the summer months, when the Allegheny salamander may become more terrestrial, the two species are not so often found together. It is also apparent that the dusky salamander often occupies situations that are not suited to its relative. At Bushnell Basin near Rochester, N. Y., the dusky salamander is particularly abundant in a sandy, spring-fed area that is well covered by a growth of water cress. Every bit of stranded bark or log harbors the dusky salamander in numbers but in these weedy areas I have never encountered a single specimen of *D. o. ochrophaeus.*

There are a number of records of birds feeding on salamanders and in one instance, at least, the Allegheny salamander furnished meals for young hermit thrushes. Coker (1931, p. 277) records such an occurrence as follows:

> In the Allegany mountains of the western part of New York state I discovered a nesting pair of exceedingly tame Hermit Thrushes. After my third day of observation the female fed her young while she was perched on my right fore-finger (along the rim of the nest). From such close quarters I had a good chance to recognize the food given to the young. I should say that on fully one-quarter of the trips made to the nest bringing food-male and female fed-salamanders were brought. I recognized both the Allegany and Red-backed salamanders in the menu. On one day when a Sharp-shinned Hawk flew low overhead, the female in excitement dropped to the forest floor a living but much bruised Allegany salamander. I noticed that during the hotter parts of the day fewer salamanders were brought and attributed this to the fact that the heat had driven the salamanders deeper under cover.

Remarks

The Allegheny salamander has as its nearest relative, the more southern *D. o. carolinensis,* and evidence of close relationship is to be noted both in structural features and habits. The relationship with *D. f. fuscus* is not so evident. Occasionally specimens are found which appear to be intermediate between the two forms although Dunn (1926, p. 118) claims to have found no evidence of intergradation. Unless there is some physiological restraint, there is nothing to prevent the females from picking up the spermatophores produced by either species for both the males of *D. f. fuscus* and *D. o. ochrophaeus* have been found producing spermatophores on the same date.

The characters by which *D. o. ochrophaeus* may be distinguished from other New York salamanders, with which it is sometimes confused, are arranged below in tabular form for convenience.

D. o. ochrophaeus	*D. f. fuscus*	*Eurycea b. bislineata*	*Plethodon cinereus*
Small, less than 100 mm	Larger, to 135 mm	Slender, to 115 mm	Long, round, to 113 mm
Mostly terrestrial	More aquatic	Usually aquatic	Terrestrial
Tail round, no keel	Tail trigonal, often with keel	Tail compressed	Tail round
Dorsal band with straight edges	Dorsal band with irregular edges	Dorsal band limited by a narrow black line each side	Dorsal band when present red, gray or yellow without black spots
Belly uniformly pigmented	Belly pale, lightly mottled	More or less yellow	Strongly pigmented and mottled
Sides bordering dorsal band dark	Sides more or less mottled	Sides mottled below black lines	Mottled
Body fairly slender	Body stout	Body slender	Body round

D. ochrophaeus was unrecognized by DeKay and Holbrook although common in the regions from which they had material. It was apparently added to the fauna of the State by Cope, (1869, p. 113) who recorded specimens from Allegany county.

Range. "Clinton county, New York to Garrett county, Maryland, west to Columbus, Ohio, in the Allegheny plateau and Appa-

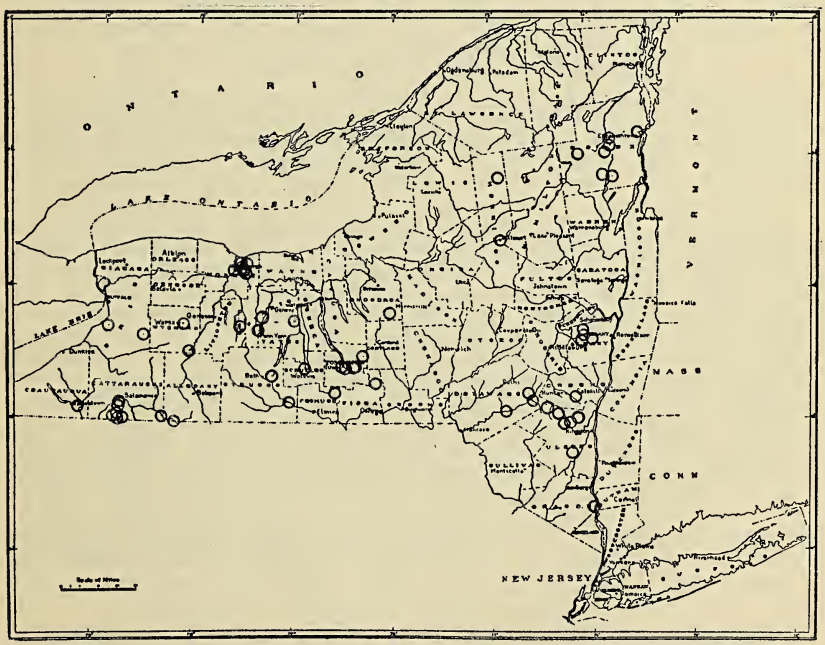

Fig. 66 New York localities for *Desmognathus ochrophaeus ochrophaeus.*

lachian valley" (Stejneger and Barbour, 1933, p. 22). Also taken in the vicinity of Monterey, Highland county, Va. (Netting, 1932, p. 101).

Distribution in New York

General. The Hudson Highlands, Ramapo and Catskill mountains, the Helderbergs, the Adirondacks, gullies and river gorges in the Ontario plain near Rochester, the Finger Lake region and Allegany State Park.

Specific records. ALBANY: (Bishop, 1923); *Altamont,* June 25, 1902, 1 ad., N. Y. S. M. No. 45 (F. C. Paulmier); *East Berne,* June 18, 1922, 2 ads.; *Thacher Park,* Aug. 31, 1927, several spec. (S. C. B. and D. Cook); *Indian ladder,* June 27, 1921 (W. J. Schoonmaker); May 27, 1923, N. Y. S. M. No. 9493 (S. C. B. and A. W.); *Voorheesville,* Apr. 5, 1924 (S. C. B. and W. J. S.). ALLEGANY: (Cope, 1869; Yarrow, 1882; Cope, 1889; Ditmars, 1905); 5 spec., U. S. N. M. No. 3917 (Dunn, 1917); 5 spec., U. S. N. M. No. 3917 (Dr Stevens); *Ceres,* Bells run, Aug. 30, 1926, N. Y. S. M. No. 3093–98. CATTARAUGUS: *Allegany State Park,* Oct. 19, 1934, many spec., U. R. No. 3439; Blacksnake mountain, July 10, 1931 (H. Jack); Aug. 3, 1931, 1 yg. (H. Jack); June 9, 1933, 7 spec., U. R. No. 3111 (S. C. B., H. Chrisp, C. Zorsch and K. Lagler); Breed's run, Aug. 18, 1926, 7 spec., N. Y. S. M. No. 3151–57; Oct. 22, 1932, several ads. and larvae; Oct. 20, 1934, 2 spec., U. R. No. 3442; Frecks, Aug. 21, 1926, 2 ads., N. Y. S. M. No. 3210–11; Mount Onondaga, Aug. 10, 1926, 5 ads., N. Y. S. M. No. 3184–88; Natural History School, Oct. 10, 1931; Oct. 19, 1935, 4 ads.; Aug. 24, 1937, sev. ads.; May 7, 1938, abdt.; Oct. 15, 1938, abdt.; Ranger trail, Oct. 10, 1931, sev.; Oct. 23, 1937, sev. ads.; Red House creek, Aug. 25, 1926, 1 ad., Red House valley, Aug. 13, 1926, 3 ads., N. Y. S. M. No. 3120–22; Stony run, Aug. 19, 1926, 3 ads., N. Y. S. M. No. 3199–201; Feb., May, Je., Oct., 1931 (Hassler, 1932), *Railroad springs,* Feb. 4, 1931 (N. M. Fuller). CHAUTAUQUA: *Poland Center,* Sept. 12, 1937, 1 ad., 1 juv. CHEMUNG: *Van Etten,* Aug. 4, 1924, N. Y. S. M. No. 1584 (S. C. B. and W. J. Schoonmaker). CLINTON: 6 spec., A. N. S. (Fowler and Dunn, 1917). DELAWARE: 1900, 2 spec., U. S. N. M. No. 57212–3 (J. Hurter); 1½ mi. E. of *Downsville,* July 1, 1935, 10 spec. U. R. No. 3881; *Halcottsville,* 1913, A. M. N. H. No. 16869–74, 76–79 (A. H. Helme). ERIE: *Hamburg,* 8 spec. (Dunn, 1917); *Holland, Three Valley Nature Reserve,* Oct. 1–16, 1930, 4 ads., U. R. 2119; 3½ mi. N. W. of *Margaretville,* July 16, 1935, U. M. No. 78860 (Bailey). ESSEX: *Ausable club,* Aug. 31, 1921, A. M. N. H. No. 14540 (C. H. Rogers); *Blue Ridge mountain,* Je.–Sept. 1926 (Weber, 1928); *Chapel Pond pass,* Je.–Sept., 1926 (Weber, 1928); *Keene Valley,* Aug. 26, 1921, 1 ad., 1 yg., A. M. N. H. No. 14541 (C. H. Rogers); near *Lake Sanford,* Je.–Sept. 1926 (Weber, 1928); *Paradox lake,* Je.–Sept. 1926 (Weber, 1928); *Westport,* 4 spec., U. S. N. M. No. 54753–6 (S. F. Baird). GREENE: *Haines Falls,* 12 spec., A. N. S. (Fowler and Dunn, 1917). HERKIMER: *Big Moose,* Aug. 13, 1904, 2 ads. (F. C. Paulmier); *Wilmurt,* Aug. 3, 1903, 8 spec., N. Y. S. M. No. 31 (F. C. Paulmier). MONROE: *Corbett's glen,* Mar. 17, 1933, 15 spec., U. R. No. 3112 (S. C. B., H. Chrisp, R. Hart and C. Zorsch); Mar. 18, 1933, ads. and yg. (S. C. B., H. Chrisp and C. Bentley); Apr. 9, 1933, 4 spec., U. R. No. 3189; Mar. 24, 1934, several, U. R. No. 3399 (C. P. Zorsch, J. Westman); *Frog Hollow,* Oct. 1, 1933, 15 spec., U. R. No. 3191; *Glen Edyth,* May 13, 1933, 3 spec., U. R. No. 3114 (H. Snearing and A. Thurston); *Rochester,* 1 ad., U. S. N. M. No. 60015 (D. W. Hubert), *Indian Falls,* May 15, 1933, 7 spec., U. R. No. 3110 (F. Clark); *Maplewood Park,* Oct. 4, 1928, many, U. R. No. 840 (S. C. B. and E. Maynard); Oct. 5, 1929, sev., U. R. No. 2141 (J. D. Hood and B. Widiker); *Palmer's glen,* May 10, 1929, sev., U. R. No. 841; Nov. 2, 1930, 10 ads., U. R. No. 1201; *Tufa glen,* June 29, 1929,

sev. ads., U. R. No. 859 (S. C. B. and R. Hart); Oct. 22, 1930, 46 ads. and juv., U. R. No. 1199; Nov. 16, 1931, sev., U. R. 2088; Mar. 12, 1933, ads. and yg., U. R. No. 3003, 3192 (S. C. B. and H. Chrisp); Oct. 1, 1933, 3 spec., U. R. No. 3193, Nov. 6, 1936, sev.; Feb. 28, 1937, (M. L. Leffler and M. R. Wright); Nov. 4, 1937, 49 just hatched; ads. and juv. ONONDAGA: *Apulia* (Britcher, 1903). ONTARIO: *Canadice lake,* July 14, 1929, 1 juv.; *Canandaigua lake,* Mentieth glen, Sept. 22, 1928, 2 spec. U. R. No. 3278 (E. A. Maynard); *Woodville,* Aug. 25, 1930, 1 ad.; Oct. 12, 1930, 6 ads.; July 13, 1935, 1 ad.; *Kashond creek,* May 20, 1932, 3 spec., Hobart college (T. T. Odell). ORANGE: *Highland Falls,* Apr. 13, 1882 (Mearns, 1898). ROCKLAND: *Rockland co.,* Apr. 4–10, 1909, 1 ad., N. Y. S. M. (A. T. Klem). SCHUYLER: *Aunt Sarah's falls,* Sept. 20, 1932, 1 ad. (J. A. Weber). STEUBEN: *Cold Spring* near Bath, June 30, 1937, abdt.; *East Corning,* June 24, 1937, 3 ads. TIOGA: *Berkshire,* 3 spec., M. C. Z. No. 4591–93 (Dunn, 1918). TOMPKINS: *Ithaca,* Je. 1904, sev., M. C. Z. No. 3158, 3163, 4525–27, (Dunn, 1918); Aug. 8, 1923 (S. C. B. and A. H. W.); July 26, 1924, N. Y. S. M. No. 1579; *Beebe lake,* June or July 1901, C. U.; Apr. 27, 1925, 1 spec. (F. Harper); *McLean bogs,* May 27, 1919, sev. (A. H. W. and S. C. B.); 1922–1925 (Leffingwell, 1926); May 2, 1934, 1 ad.; *Ringwood,* Aug. 8, 1923 (S. C. B. and A. H. W.); *Turkey hill,* Apr. 18, 1920, C. U. ULSTER: *Lake Mohonk,* Aug. 26, 1927, (J. A. Weber); *Pine Hill,* 1880–1882 (Bicknell, 1882); *Shokan,* 4 spec., A. M. N. H. No. 422–4, 429, (Dunn, 1917); *West Shokan,* July 30, 1909, 1 spec., A. M. N. H. No. 2222 (A. L. Treadwell); Aug. 3, 1909, 1 spec., A. M. N. H. No. 2223 (A. L. Treadwell); Aug. 25, 1909, 1 spec., A. M. N. H. No. 2230 (A. L. Treadwell); *Woodland,* May 30, 1926, sev. (W. J. S.); *Woodstock,* 1918, 6 spec., U. S. N. M. No. 61120–26 (E. Uhlenhuth). WYOMING: *Letchworth Park,* May 18, 1932, many ads., U. R. No. 2485; Oct. 7, 1933, 12 yg., U. R. No. 3190 (S. C. B. and B. Bishop); *Warsaw,* June 6, 1937, sev. (Van Auken).

Records too indefinite to be placed under counties. *New York,* (Boulenger, 1882); found in the *Adirondacks* and *Catskills* (Eckel and Paulmier, 1902); *Catskills,* 1 spec., U. S. N. M. No. 23192 (Dunn, 1917); 1 spec., U. S. N. M. No. 54752 (E. A. Mearns).

Condensed Bibliography

Life history and habits. Bishop, 1927, p. 59 (*Desmognathus fuscus ochrophaeus*); Bishop and Chrisp, 1933, p. 194–98; Cope, 1869, p. 113–15 (*Desmognathus ochrophaea*); Cope, 1889, p. 191–94; Ditmars, 1905, p. 177; Dunn, 1917, p. 415 (*Desmognathus o. ochrophaea*); Dunn, 1926, p. 117 (*Desmognathus fuscus ochrophaeus*).

Distribution in New York. Bicknell, 1882, p. 124 (*Desmognathus ochrophaea*) Bishop, 1923, p. 67 (*Desmognathus ochrophaeus*); Bishop, 1927, p. 60 (*Desmognathus fuscus ochrophaeus*); Bishop and Chrisp, 1933, p. 194–98; Boulenger, 1882, p. 77 (*Desmognathus ochrophaeus*); Britcher, 1903, p. 121 (*Desmognathus ocrophaea (sic)*); Cope, 1869, p. 113 (*Desmognathus ochrophaea*); Cope, 1889, p. 193; Dunn, 1917, p. 417 (*Desmognathus ochrophaeus*); Dunn, 1918, p. 464 (*Desmognathus o. ochrophaea*); Dunn, 1926, p. 119 (*Desmognathus fuscus ochrophaeus*); Eckel and Paulmier, 1902, p. 402 (*Desmognathus ochrophaea*); Fowler and Dunn, 1917, p. 22; Hassler, 1932*a*, p. 305 (*Desmognathus fuscus ochrophaeus*); Leffingwell, 1926, p. 72 (*Desmognathus o. ochrophaeus*); Mearns, 1898, p. 324 (*Desmognathus ochrophaea*); Weber, 1928, p. 107 (*Desmognathus fuscus ochrophaeus*); Yarrow, 1882, p. 159 (*Desmognathus ochrophaea*).

General. Netting, 1932, p. 101 (*Desmognathus fuscus ochrophaeus*); Fowler, 1906, p. 356 (*Desmognathus fuscus*).

BIBLIOGRAPHY

Abbott, C. C.

1884 A Naturalist's Rambles about Home. Appleton. New York, p. 1–485

Alexander, W. P.

1927 The Allegheny Hellbender and Its Habitat. Hobbies, Buffalo Soc. of Nat. Sci., 7:13–18, 3 figs.

Allen, J. A.

1869 Catalogue of the Reptiles and Batrachians Found in the Vicinity of Springfield, Mass., with Notices of All the Other Species Known to Inhabit the State. Proc. Bost. Soc. Nat. Hist., 12:171-204

Andrews, E. A.

1897 Breeding Habits of the Spotted Salamander. Amer. Nat., 31:635-37

Baird, S. F.

1850 Revision of the North American Tailed-Batrachia, with Descriptions of New Genera and Species. Jour. Acad. Nat. Sci. Phila. 2d ser., 1:281-94

1852 List of Specimens of Living Salamanders Presented to the State Cabinet of Natural History. 5th Ann. Rep't State Cab. Nat. Hist., p. 21–22

Barbour, Thomas

1914 An Unusual Red Salamander. Copeia, No. 10, Sept. 1914

Barnes, D. H.

1826 An Arrangement of the Genera of Batracian Animals, with a Description of the More Remarkable Species. . . Amer. Jour. Sci., 11:268–97

1828 Note on the Doubtful Reptils. Amer. Jour. Sci., 13:66–68

Barton, B. S.

1807 Miscellaneous Facts and Observations. Natural History: Zoology. Phila. Med. and Phys. Jour. 2d supplement, 3:196–97

Bicknell, E. P.

1882 A Review of the Summer Birds of a Part of the Catskill Mountains, with Prefatory Remarks on the Faunal and Floral Features of the Region. Trans. Linn. Soc. New York, 1:115–68

Bishop, S. C.

1919 Notes on the Habits and Development of the Four-toed Salamander, *Hemidactylium scutatum* (Schlegel). N. Y. State Mus. Bul., 219, 220:251–82

1923 Notes on the Herpetology of Albany County, New York. Copeia, No. 118, p. 64–68

1924 Notes on Salamanders. N. Y. State Mus. Bul., 253:87–96, pls. 1–3

1925 The Life of the Red Salamander. Natural History, 25(4):385–89

1925*a* Records of Some Salamanders from North Carolina and Pennsylvania. Copeia, No. 139, p. 9–12

1926 Notes on the Habits and Development of the Mudpuppy, *Necturus maculosus* (Rafinesque). N. Y. State Mus. Bul. 268, p. 5–60, pls. 1–11

1927 The Amphibians and Reptiles of Allegany State Park. N. Y. State Mus. Handbook, 3: 5-134, figs. 1-58

1932 The Spermatophores of *Necturus maculosus* Rafinesque. Copeia, No. 1, p. 1–3, figs. 1–3

———— & Chrisp, H. P.

1933 The Nests and Young of the Allegheny Salamander, *Desmognathus fuscus ochrophaeus* (Cope). Copeia, No. 4, p. 194–98, figs. 1–5

Blanchard, F. C.

1932 Length of Life in the Tiger Salamander, *Ambystoma tigrinum*. Copeia, No. 2, p. 98

Blanchard, F. N.

1922 Discovery of the Eggs of the Four-toed Salamander in Michigan. Occ. Papers, Mus. Zool. Univ. Mich., No. 126, p. 1–3

1923 The Life History of the Four-toed Salamander. Amer. Nat., 57:262–68

1928 Amphibians and Reptiles of the Douglas Lake Region in Northern Mich. Copeia, No. 167, p. 42–51

1928*a* Topics from the Life History and Habits of the Red-backed Salamander in Southern Michigan. Amer. Nat., 62:156–64, figs. 1–4

1930 The Stimulus to the Breeding Migration of the Spotted Salamander, *Ambystoma maculatum* (Shaw). Amer. Nat., 64:154–67

1933 Spermatophores and the Mating Season of the Salamander *Hemidactylium scutatum* (Schlegel). Copeia, No. 1, p. 40

1933*a* Late Autumn Collections and Hibernating Situations of the Salamander *Hemidactylium scutatum* (Schlegel) in Southern Michigan. Copeia, No. 4, p. 216-17

1934 The Spring Migration of the Four-toed Salamander, *Hemidactylium scutatum* (Schlegel). Copeia, No. 1, p. 50

1934*a* The Date of Egg-laying of the Four-toed Salamander *Hemidactylium scutatum* (Schlegel) in Southern Michigan. Papers Mich. Acad. Sci. Arts and Letters, 19:571–75

1934*b* The Relation of the Female Four-toed Salamander to Her Nest. Copeia, No. 3, p. 137–38

1935 The Sex Ratio in the Salamander, *Hemidactylium scutatum* (Schlegel). Copeia, No. 2, p. 103

1936 The Number of Eggs Produced and Laid by the Four-toed Salamander, *Hemidactylium scutatum* (Schlegel), in Southern Michigan. Papers Mich. Acad. Sci. Arts and Letters, 21:567–73, pl. 57, figs. 1–2, text figs. 24–26

———— **& Blanchard, F. C.**

1931 Size Groups and Their Characteristics in the Salamander *Hemidactylium scutatum* (Schlegel). Amer. Nat., 65:149–64

Boulenger, E. G.

1914 Reptiles and Batrachians, p. 3–278, many illustrations. Dutton, New York

Boulenger, G. A.

1882 Catalogue of the Batrachia Gradientia S. Caudata and Batrachia Apoda in the Collection of the British Museum. 2d ed. p. 1–127, pl. 1–9

Boyle, H. S.

1914 Four-toed Salamander on Long Island. Copeia, No. 9

Branin, M. L.

1935 Courtship Activities and Extra-Seasonal Ovulation in the Four-toed Salamander, *Hemidactylium scutatum* (Schlegel). Copeia, No. 4, p. 172–75

Breder, C. M. & Breder, R. B.

1923 A List of Fishes, Amphibians and Reptiles Collected in Ashe County, North Carolina. Zoologica, 4(1):3–23

Breder, R. B

1927 The Courtship of the Spotted Salamander. Zool. Soc. Bul., 30:51–56, 1 pl., 9 figs.

Brimley, C. S.

1896 Batrachia Found at Raleigh, N. C. Amer. Nat., 30: 500–1
1916 The Two Raleigh Amblystomae Compared. Bul. Elisha Mitchell Sci. Soc., 32:45–46
1920 Reproduction of the Marbled Salamander. Copeia, No. 80, p. 25
1921 Breeding Dates of *Ambystoma maculatum* at Raleigh, N. C. Copeia, No. 93, p. 26–27
1921*a* The Life History of the American Newt. Copeia, No. 94, p. 31–32
1924 The Water Dogs (Necturus) of North Carolina. Jour. Elisha Mitchell Sci. Soc., 40: 166–68

Britcher, H. W.

1903 Batrachia and Reptilia of Onondaga County. Proc. Onon. Acad. Sci., 1: 120–22

Burger, J. W.

1935 *Plethodon cinereus* (Green) in Eastern Pennsylvania and New Jersey. Amer. Nat., No. 725, 69:578–586

Burt, C. E.

1931 A Report on Some Amphibians and Reptiles from New York and New Jersey. Jour. Wash. Acad. Sci., 21:198–203
1932 Records of Amphibians from the Eastern and Central United States (1931). The American Midland Naturalist, 13:75–85

Clanton, Wesley

1934 An Unusual Situation in the Salamander *Ambystoma jeffersonianun* (Green). Occ. Papers Mus. Zool. Univ. Mich., No. 290, p. 1–14, pl. 1, fig. 1

Clarke, S. F.

1880 Development of *Amblystoma punctatum*. Studies of Biol. Lab. Johns Hopkins Univ. 1:105–25, pls. 1–4, figs. 1–31

Cochran, D. M.

1930 *in,* Cold-Blooded Vertebrates. Smithsonian Scientific Series, 8(2–3): 1–375, pls. 1–81, text figs. 1–88

Cochran, M. E.

1911 The Biology of the Red-backed Salamander *Plethodon cinereus erythronotus* (Green). Biol. Bul., 20(6): 332–49, 11 figs.

Coker, C. M.

1931 Hermit Thrush Feeding on Salamanders. The Auk, 48:277

Cope, E. D.

1860 On the Primary Divisions of the Salamandridae, with Descriptions of Two New Species. Proc. Acad. Nat. Sci. Phila., for 1859, p. 112–28
1867 A Review of the Species of the Amblystomidae. Proc. Acad. Nat. Sci. Phila., p. 166–211
1869 A Review of the Species of Plethodontidae and Desmognathidae. Proc. Acad. Nat. Sci. Phila., p. 93–118
1885 "Batrachia" in The Standard Natural History, *ed. by* J. S. Kingsley. 3:303–44, figs. 170–205. Boston
1889 The Batrachia of North America, U. S. Nat. Mus. Bul., 34, p. 3–525, pls. 1–79, 83, 86, figs. 1–119

Corrington, J. D.

1931 Abnormal Herpetological Specimens from Syracuse, New York. Amer. Nat., 65:77–85

Cox, Philip

1898 Batrachia of New Brunswick. Bull. Nat. Hist. Soc. New Brunswick, No. 16, 4:64–66

Daudin, F. M.

1803 Historie Naturelle des Reptiles, 8: 1–439

Davis, Wm. T.

1884 The Reptiles and Batrachians of Staten Island. Proc. Nat. Sci. Ass'n Staten Is., 1:13

1903 The Four-toed Salamander on Staten Island. Proc. Nat. Sci. Ass'n Staten Is., 9(2):4

1908 Notes on New Jersey Amphibians and Reptiles. Proc. Staten Island Ass'n Arts and Sci., 2(2):47–52

1923 Proc. Staten Island Ass'n Arts and Sci., 1(4):129

1927 Natural History Records from the Meetings of the Staten Island Nature Club. Proc. Staten Island Inst. Arts and Sci., 4:65–76

1928 Proc. Staten Island Inst. Arts and Sci., 4(4):121

1933 Natural History Records from The Meetings of the Staten Island Nature Club. Proc. Staten Island Inst. Arts and Sci., 6:166

Deckert, R. F.

1914 Salamanders Collected in Westchester County, N. Y. Copeia, No. 13, Dec. 15, 1914

1916 Note on *Amblystoma opacum* Grav. Copeia, No. 28, p. 23–24

1917 Another Record of *Amblystoma opacum* from Long Island. Copeia, No. 41, p. 24

DeKay, J. E.

1842 Zoology of New York. Part 3, Reptiles and Amphibia, p. 1–98, pls. 1–23 (Text and plates in separate volumes).

Dempster, W. T.

1930 The Growth of Larvae of *Ambystoma maculatum* under Natural Conditions. Biol. Bul., 58:182–92, fig. 1–3. 1 table

Dieckmann, J. M.

1927 The Cloaca and Spermatheca of *Gyrinophilus porphyriticus*. The Biol. Bul., 53(4):258–80, pls. 1–3

1927*a* The Cloaca and Spermatheca of *Hemidactylium scutatum*. Biol. Bul., 53(4):281–85

Ditmars, R. C.

1905 The Batrachians of the Vicinity of New York City. Amer. Mus. Jour., 5:161–206, figs. 1–28

Dunn, E. R.

1915 The Transformation of *Spelerpes ruber* (Daudin). Copeia, No. 21, p. 28–30

1917 The Breeding Habits of *Ambystoma opacum* (Gravenhorst). Copeia, No. 43, p. 40–43

1917*a* The Salamanders of the Genera *Desmognathus* and *Leurognathus*. Proc. U. S. Nat. Mus., 53:393–433

1918 The Collection of Amphibia Caudata of the Museum of Comparative Zoology. Bul. Mus. Comp. Zool., 62:445–71

1918*a* Notes on Some Larval Salamanders. Copeia, No. 53, p. 12

1919 *Ambystoma opacum* at Florence, Mass. Copeia, No. 70, p. 51–52

1920 The Red Salamander. Aquatic Life, 5:119–20, 1 fig.

1920*a* Some Reptiles and Amphibians from Virginia, North Carolina, Tennessee and Alabama. Proc. Biol. Soc. Wash., 33:133

1926 The Salamanders of the Family Plethodontidae. Smith College 50th Anniversary Pub. Northampton, Mass. 1926, p. v–viii, 1–441, 86 maps, frontispiece

1927 On the Relationships of Certain Plethodont Salamanders. Copeia, No. 165, p. 102–6

1930 Reptiles and Amphibians of Northampton and Vicinity. Bul. Boston Soc. Nat. Hist., No. 57, p. 3

Eckel, E. C. & Paulmier, F. C.

1902 Catalogue of New York Reptiles and Batrachians. N. Y. State Mus. Bul., 51:355–414, pl. 1, text figs. 1–24

Eights, James

1835 Naturalist's Everyday Book. The Zodiac, 1:6

1836 Naturalist's Everyday Book. The Zodiac, 1:130

Engelhardt, G. P.

1913 Children's Museum News, 1:3

1914 *Amblystoma* of Long Island. Copeia, No. 8

1916 *Amblystoma tigrinum* on Long Island, I. Copeia, No. 28, p. 20–22

1916*a* *Amblystoma tigrinum* on Long Island. II. Copeia, No. 30, p. 32–35

1916*b* *Amblystoma tigrinum* on Long Island. Copeia, No. 32, p. 48–51

1916*c* *Amblystoma opacum* on Long Island. Copeia, No. 37, p. 88–89

1917 Another Long Island Record for *Amblystoma jeffersonianum* (Green). Copeia, No. 50, p. 98

1919 The Habitat of *Gyrinophilus porphyriticus*. Copeia, No. 69, p. 20–21

Evermann, B. W.

1918 Notes on Some Adirondack Reptiles and Amphibians. Copeia, No. 56, p. 48–51

Eycleshymer, A. C.

1895 The Early Development of Amblystoma, with Observations on Some other Vertebrates. Jour. Morph., 10:343–418, pls. 18–22, fig. 1–4

1904 Bilateral Symmetry in the Egg of Necturus. Anat. Anz., 25:230–40, figs. 1–47

1906 The Habits of *Necturus maculosus*. Amer. Nat., 40:123–36

Fisher, G. C.

1918 Note on the Dusky Salamander. Copeia, No. 58, p. 65–66

Fowler, H. W.

1906 Note on the Dusky Salamander. Proc. Acad. Nat. Sci. Phila., 58: 356–57, pl. 13, figs. 1–5

1907 The Amphibians and Reptiles of New Jersey. Ann. Rep't N. J. State Mus. Pt 2. p. 23–250, pls. 1–69, text figs.

———— & Dunn, E. R.

1917 Notes on Salamanders. Proc. Acad. Nat. Sci. Phila., 69:7–28, pls. 3–4

Fowler, J. A.

1940 A Note on the Eggs of *Plethodon glutinosus*. Copeia, No. 2, p. 133.

Gadow, Hans

1923 Amphibia and Reptiles. The Cambridge Nat. Hist., 8:iii–xiii, 3–668, figs. 1–181, map

Gage, S. H.

1891 The Changes of the Salamander *Diemyctylus viridescens*. Amer. Nat., 25:380

1891*a* Life-History of the Vermilion-spotted Newt. Amer. Nat., 25:1084–1110, pl. 23, figs. 1–11

———— & Norris, H. W.

1891 Notes on the Amphibia of Ithaca. Proc. Amer. Ass'n Adv. Sci. 39:338–39

Gebhard, John

1856 9th Ann Rep't State Cab. Nat. Hist., p. 16–18

Goodale, H. D.

1911 The Early Development of *Spelerpes bilineatus* (Green). Amer. Jour. Anat., 12(2):173–247, figs. 1–77, 1 pl.

Grant, M. P.
1931 Diagnostic Stages of Metamorphosis in *Amblystoma jeffersonianum* and *Amblystoma opacum*. Anat. Rec., 51:1–15, pls. 1–3

Gravenhorst, Johann
1807 Vergl. Uebers. Zool. Syst., p. 431

Green, H. T.
1923 Notes on Middle States Amphibians and Reptiles. Copeia, No. 122, p. 99
1925 The Egg-Laying of the Purple Salamander. Copeia, No. 141, p. 32

Green, Jacob
1818 Descriptions of Several Species of North American Amphibia, Accompanied with Observations. Jour. Acad. Nat. Sci. Phila., 1(2):348–59
1827 An Account of Some New Species of Salamanders. Contr. Maclur. Lyc., 1:4, pl. 1, fig. 1

Hallowell, Edward
1856 Proc. Acad. Nat. Sci. Phila., May 1856, p. 101

Hamilton, W. J.
1932 The Food and Feeding Habits of Some Eastern Salamanders. Copeia, No. 2, July, p. 83–86
1936 Seasonal Food of Skunks in New York. Jour. Mammalogy, 17(3):243

Harlan, Richard
1825 Observations on the Genus Salamandra, with the Anatomy of the *Salamandra gigantea* (Barton) or *S. alleghaniensis* (Michaux) and Two New Genera Proposed. Ann. Lyc. Nat. Hist. N. Y., 1:222–34, pls. 16–18
1827 Genera of North American Reptilia, and a Synopsis of the Species. Jour. Acad. Nat. Sci. Phila., 5:317–72
1835 Genera of North American Reptilia, and a Synopsis of the Species. Med. and Phys. Resources, p. 84–163, figs. 1–4
1835*a* Observations on the Genus Salamandra, and the Establishment of the Genera *Menopoma* and *Menobranchus*. Med. and Physical Researches, p. 164–76, 2 pls.

Hassler, W. G.
1932 New Locality Records for Two Salamanders and a Snake in Cattaraugus County, New York. Copeia, No. 2, July, p. 94–96
1932*a* Salamanders and Water Hygiene. Nat Hist., 32(3): 303–10, figs. 1–10

Hay, O. P.
1889 Notes on the Habits of Some Amblystomas. Amer. Nat., 23:602–12
1892 The Batrachians and Reptiles of the State of Indiana. 17th Ann. Rep't Geol. and Nat. Res. Ind., p. 409–602, pls. 1–3

Hilsman, H. M.
1935 Nawakwa Fireside, n.s., No. 3–4, p. 1–13

Hilton, W. A.
1902 A Structural Feature Connected with the Mating of *Diemyctylus viridescens*. Amer. Nat., 36:643–51
1904 Segmentation of the Ovum of *Desmognathus fusca*. Amer. Nat., 38:498–500, figs. 1–8
1909 General Features of the Early Development of *Desmognathus fusca*. Jour. Morph., 20:533–47, pls. 1–6

Holbrook, J. E.
1842 North American Herpetology, 2d ed. 5v. Phila.

Hood, H. H.

1934 A Note on the Red-backed Salamander at Rochester, New York. Copeia, No. 3, p. 141–42

Hough, F. B.

1852 Catalogue of Reptiles and Fishes from St Lawrence County. Procured for the N. Y. State Cabinet of Natural History. 5th Ann. Rep't State Cab. Nat. Hist., p. 23–28

Hoy, P. R.

1871 The Development of *Amblystoma lurida* Sager. Amer. Nat., 5:578–79

Hughes, Edward

1886 Bul. Brookville Soc. Nat. Hist., 2:40

Humphrey, R. R.

1928 Ovulation in the Four-toed Salamander, *Hemidactylium scutatum*, and the External Features of Cleavage and Gastrulation. Biol. Bul., 54:307–23, figs. 1–8

Hurter, Julius

1903 Second Contribution to the Herpetology of Missouri. Trans. Acad. Sci. St Louis, 13:77–86

1911 Herpetology of Missouri. Trans. Acad. Sci. St Louis, 20(5):59–274, pls. 18–24

Jordan, E. O.

1891 The Spermatophores of Diemyctylus. Jour. Morph., 5:263–70

1893 The Habits and Development of the Newt (*Diemyctylus viridescens*). Jour. Morph., 8:269–366, pls. 14–18

King, Willis

1935 Ecological Observations on *Ambystoma opacum*. Ohio Jour. Sci., 35(1):1–14, 1 pl.

Kingsbury, B. F.

1895 The Spermatheca and Methods of Fertilization in Some American Newts and Salamanders. Trans. Amer. Micros. Soc., 17:261–98, pls. 1–4

1902 The Spermatogenesis of *Desmognathus fuscus*. Amer. Jour. Anat., 1(2):99–135

Kline, E. K. & Fuller, N. M.

1932 Interpretation of Laboratory Findings in Rural Spring Water Supplies. Amer. Jour. Public Health, 22(7):691–99, figs. 1–5

Kneeland, Samuel

1857 Proc. Bost. Soc. Nat. Hist., 6:154

1859 On a Supposed New Species of Siredon from Lake Superior, *Siredon hyemalis*. Proc. Bost. Soc. Nat. Hist., 6:152–54

Koehring, Vera

1925 The Spermatheca of *Eurycea bislineata*. Biol. Bul., 49:250–64, pls. 1–2

Kumpf, K. F.

1934 The Courtship of *Ambystoma tigrinum*. Copeia, No. 1, p. 7–10

———— & Yeaton, S. C.

1932 Observations on the Courtship Behavior of *Ambystoma jeffersonianum*. Amer. Mus. Novitates, No. 546, p. 1–7, figs. 1–3

Lantz, L. A.

1930 Notes on the Breeding-Habits and Larval Development of *Ambystoma opacum* Grav. Ann. and Mag. Nat. Hist., 5:322–25, 2 figs.

1930*a* Einiges über Lebensweise und Fortpflanzung von *Ambystoma opacum* Grav. Blatt. f. Aquar. u. Terrarienkunde, 41:63–67, 2 pls.

Leffingwell, D. J.

1926 *Vertebrates* in: A Preliminary Biological Survey of the Lloyd-Cornell Reservation. Bul. 27 (Ent. Ser. 5.) Lloyd Library of Botany, Pharmacy and Materia Medica. p. 3–247, pls. 1–13, figs. 1–15.

Lindsay, J. H.

1844 A Catalogue of the Reptiles of Connecticut, Arranged According to Their Natural Families. Amer. Jour. Sci. and Arts, 46:37–51

McAtee, W. L.

1907 A List of the Mammals, Reptiles and Batrachians of Monroe County, Indiana. Proc. Biol. Soc. Wash., 20:1–16.

1933 Notes on the Banded Salamander (*Ambystoma opacum*). Copeia, No. 4, p. 218–19

McGregor, J. H.

1896 An Embryo of *Cryptobranchus*. Trans. N. Y. Acad. Sci., 16:73

Mann, Charles

1855 On the Habits of a Species of Salamander (*Amblystoma opacum* Bd.). 9th Ann. Rep't Smithsonian Inst. p. 294–95

Marshall, W. B.

1892 *Necturus maculatus* in the Hudson River. Amer. Nat., 26:779–80.

1894 *Necturus maculatus* in the Hudson River. 47th Ann. Rep't N. Y. State Mus., p. 33–34

Matheson, Robert, & Hinman, E. H.

1929 The Vermilion Spotted Newt (*Diemyctylus viridescens* Rafinesque) As an Agent in Mosquito Control. Amer. Jour. Hygiene, 9:188–91

Mearns, W. A.

1898 A Study of the Vertebrate Fauna of the Hudson Highlands, with Observations on the Mollusca, Crustacea, Lepidoptera, and the Flora of the Region. Bul. Amer. Mus. Nat. Hist., 10:303–52

1898*a* Notes on the Mammals of the Catskill Mountains, New York, with General Remarks on the Fauna and Flora of the Region. Proc. U. S. Nat. Mus., 21:341–60, figs. 1–6

Mellen, Ida

1927 The Amphibians. Bul. N. Y. Zool. Soc., 30:172–205, 27 pls.

Merriam, C. H.

1882 The Vertebrates of the Adirondack Region, Northeastern New York. Tran. Linn. Soc. N. Y., 1:5–106

Mitchill, S. L.

1822 The Proteus of the North-American Lakes. Amer. Jour. Sci., 4:181–85

1824 Observations on Several Reptiles of North America, Which Seem To Belong to the Family of Proteus. Amer. Jour. Sci., 7:63–69, pl. 2, figs. 1–3

Mohr, Charles E.

1930 The Ambystomid Salamanders of Pennsylvania. Proc. Penna. Acad. Sci., 4:50–55

1931 Observations on the Early Breeding Habits of *Ambystoma jeffersonianum* in Central Pennsylvania. Copeia, No. 3, Oct., p. 102–4

Monks, S. P.

1880 The Spotted Salamander. Amer. Nat., 14:371–74

Montgomery, Henry

1879 Some Observations of the *Menobranchus maculatus*. Can. Nat. n. s., 9(3):160–64

Montgomery, T. H.

1901 Peculiarities of the Terrestrial Larva of the Urodelous Batrachian, *Plethodon cinereus* Green. Proc. Acad. Nat. Sci. Phila., 53:503–8, pl. 30, figs. 1–5

Morgan, A. H. & Grierson, M. C.

1932 Winter Habits and Yearly Food Consumption of Adult Spotted Newts, *Triturus viridescens*. Ecology, 13:54–62, figs. 1–4

Morse, Max

1901 Ohio Batrachia in the Zoological Museum of the O. S. U. Ohio Nat. 1(7):114–15

1904 Batrachians and Reptiles of Ohio. Proc. Ohio State Acad. Sci., 4:94–141, pl. 1, 3 text figs.

Murphy, R. C.

1917 The Jumping Ability of Plethodon and Its Possible Bearing upon the Origin of Saltation in the Ancestors of the Anura. Copeia, No. 51, p. 105–6

1918 The Food of *Plethodon cinereus*, Copeia, No. 52, p. 8

Myers, G. S.

1930 Amphibians and Reptiles Observed in the Palisades Interstate Park, New York and New Jersey. Copeia, No. 173, p. 99–103

Netting, M. G.

1928 A Preliminary List of Amphibians and Reptiles of Cook Forest, Clarion and Forest Counties, Pennsylvania. The Cardinal, Jan. 1928

1929 The Food of the Hellbender, *Cryptobranchus alleganiensis* (Daudin). Copeia, No. 170, p. 23–24

1932 *Desmognathus fuscus ochrophaeus* in Virginia. Copeia, No. 2, p. 101

1933 The Amphibians of Pennsylvania. Proc. Penna. Acad. Sci., 7:100–10

Nichols, J. S.

1925 A Balancer in Larvae of *Amblystoma tigrinum*. Amer. Nat., 59:191–92

Noble, G. K.

1926 The Long Island Newt: A Contribution to the Life History of *Triturus viridescens*. Amer. Mus. Novitates, No. 228, p. 1–11, figs. 1–3

1927 Distributional List of the Reptiles and Amphibians of the New York City Region. Amer. Mus. Nat. Hist. Guide Leaflet, Ser. No. 69, p. 1–9

1927*a* The Value of Life-History Data in the Study of the Evolution of the Amphibia. Annals of the New York Academy of Sciences, 30:31–128, pl. 9

1929 Further Observations on the Life-History of the Newt, *Triturus viridescens*. Amer. Mus. Novitates, No. 348, p. 1–22, figs. 1–7

1929*a* The Relation of Courtship to the Secondary Sexual Characters of the Two-lined Salamander, *Eurycea bislineata* (Green). Amer. Mus. Novitates, No. 362, p. 1–5, figs. 1–4

1931 Biology of the Amphibia, p. vii–xiii, 1–577, figs. 1–174, frontispiece. McGraw-Hill. New York

1931*a* The Hedonic Glands of the Plethodontid Salamanders and their Relation to Sex Hormones. Anat. Rec., 48:57–58

——— & Brady, M. K.

1930 The Courtship of the Plethodontid Salamanders. Copeia No. 2, p. 52–54

1930*a* The Mechanism of Hatching in the Marbled Salamander. Anat. Record, 45:274

1933 Observations on the Life History of the Marbled Salamander, *Ambystoma opacum* Gravenhorst. Zoologica, 11:89–132, figs. 83–93

——— & Evans, Gertrude

1932 Observations and Experiments on the Life History of the Salamander, *Desmognathus fuscus fuscus* (Rafinesque). Amer. Mus. Novitates, No. 533, p. 1–16

——— & Marshall, B. C.

1929 The Breeding Habits of Two Salamanders. Amer. Mus. Novitates, No. 347, p. 1–12, figs. 1–4

——— & Richards, J. A.

1930 The Induction of Egg-laying in the Salamander, *Eurycea bislineata,* by Pituitary Transplants. Amer. Mus. Novitates, No. 396, p. 1–3

1932 Experiments on the Egg-laying of Salamanders. Amer. Mus. Novitates, No. 513, p. 1–25, figs, 1–7

1932*a* Effect of Anterior Pituitary upon Production of Red Pigment in the Salamander, *Pseudotriton ruber ruber* (Sonnini). Proc. Soc. Exp. Biol. and Med., 30:9–11

——— &Weber, J. A.

1929 The Spermatophores of Desmognathus and other Plethodontid Salamanders. Amer. Mus. Novitates, No. 351, p. 1–15, figs. 1–4

O'Donnell, D. J.

1937 Natural History of the Ambystomid Salamanders of Illinois. Amer. Midland Nat., 18(6):1063–71

Okey, K. W.

1916 The Relation of the Profundus and Gasserian Ganglia in the Embyro of the Urodele, *Plethodon glutinosus.* Ohio Jour. Sci., 17:25–51. The species concerned was apparently *Ambystoma texanum*

Orr, Henry

1889 Note on the Development of Amphibians. Quart. Jour. Micros. Sci., 29:295–324

Pearse, A. S.

1921 Habits of the Mud-Puppy, *Necturus,* an Enemy of Food Fishes. Bureau of Fisheries, Economic Circular No. 49, p. 1–8, 1 fig.

Piatt, Jean

1931 An Albino Salamander. Copeia, No. 1, p. 29

Piersol, W. H.

1910 Spawn and Larva of *Ambystoma jeffersonianum.* Amer. Nat., 44: 732–38, figs. 1–4

1910*a* The Habits and Larval State of *Plethodon cinereus erythronotus.* Trans. Can. Inst., 8:469–93, figs. 1–14

1914 The Egg-laying Habits of *Plethodon cinereus.* Trans. Royal Can. Inst., 10:21–26

1929 Pathological Polyspermy in Eggs of *Ambystoma jeffersonianum* (Green). Trans. Royal Can. Inst., 17:57–74, pl. 1, fig. 1

Pike, N. M.

1886 Some Notes on the Life-History of the Common Newt. Amer. Nat., 20:17–25

1886*a* Notes on the Life History of *Amblystoma opacum.* Bul. Amer. Mus. Nat. Hist., 1: 209–12

Pope, P. H.

1915 Some New Records for *Gyrinophilus porphyriticus* (Green). Copeia, No. 19, p. 14–15

1916 Winter Activity of *Amblystoma punctatum* (Baird). Copeia, No. 30, p. 35

1919 A Note on the Length of Life of Some Batrachians in Captivity. Copeia, No. 72, p. 66

1921 Some Doubtful Points in the Life-History of *Notophthalmus viridescens*. Copeia, No. 91, p. 14–15

1924 The Life-History of the Common Water-Newt (*Notophthalmus viridescens*), together with Observations on the Sense of Smell. Ann. Carnegie Mus., 15:305–68, pls. 41–51

1928 The Life-History of *Triturus viridescens*—Some Further Notes. Copeia, No. 168, p. 61–72

1928*a* The Longevity of *Ambystoma maculatum* in Captivity. Copeia, No. 169, p. 99–100

1937 Notes on the Longevity of an *Ambystoma* in Captivity. Copeia, No. 2, p. 140–41

———— & Noble, G. K.

1921 Purple Salamander. Copeia, No. 100, p. 79–80

Putnam, F. W.

1865 Proc. Bost. Soc. Nat. Hist., (1863)9:173

Rafinesque, C. S.

1818 Further Account of Discoveries in Natural History, in the Western States. Amer. Month. Mag. Crit. Rev., 4:39–42

1820 Annals of Nature, Lexington, Ky. No. 1, p. 1–16

Reed, H. D.

1908 A Note on the Coloration of *Plethodon cinereus*. Amer. Nat., 42:460–64, figs. 1–7

———— & Wright, A. H.

1909 The Vertebrates of the Cayuga Lake Basin, N. Y. Proc. Amer. Phil. Soc., 48:370–459, pls. 17–20

Reese, A. M.

1903 The Habits of the Giant Salamander. Popular Sci. Monthly, 62:526–31

1904 The Sexual Elements of the Giant Salamander, *Cryptobranchus allegheniensis*. Biol. Bul. 6:220–23, figs. 1–3

1906 Observations on the Reactions of Cryptobranchus and Necturus to Light and Heat. Biol. Bul., 11:93–99

1906*a* Anatomy of *Cryptobranchus allegheniensis*. Amer. Nat., 40:287–326, figs. 1–13

1912 Food and Chemical Reactions of the Spotted Newt. Jour. Animal Behavior, 2:190–208

1916 Variations in the Vermilion-Spotted Newt, *D. viridescens*. Amer. Nat., 50:316–19, figs. 1–24

Ridgway, Robert

1912 Color Standards and Color Nomenclature. Wash., D. C. p. i–iii, 1–44, pls. 1–53

Rogers, C. S.

1906 A Chameleon-like Change in *Diemyctylus*. Biol. Bul., 10: 165

Ruthven, A. G.

1909 The Cold-blooded Vertebrates of Isle Royale. An Ecological Survey of Isle Royale, Lake Superior prepared under the direction of C. C. Adams. Lansing, Michigan, p. 329–33

Ruthven, A. G., Thompson, Crystal, & Gaige, H. T.

1928 The Herpetology of Michigan, Michigan Handbook Ser. No. 3, University Museums, Univ. of Michigan, p. iii–ix, 1–228, pls. 1–19, 52 text figs.

Ruthven, A. G., Thompson, Crystal, & Thompson, Helen

1912 The Herpetology of Michigan. Pub. 10, Biol. Ser. 3, Mich. Geol. and Biol. Survey, p. 1–166, pls. 1–20, 55 text figs.

Say, Thomas

1818 Notes on Professor Green's Paper on the Amphibia, published in the September number of this Journal. Jour. Acad. Nat. Sci. Phila., 1: 405–7

Schneider, J. G.

1799 Historiae Amphibiorum Naturalis et Literariae, p. i-xiii, 1–264, pls. 1–2, Jena

Shaw, George

1802 Gen. Zool., 3:1–312, pls. 1–86

Shelford, V. E.

1913 The Reactions of Certain Animals to Gradients of Evaporating Power of Air. A Study in Experimental Ecology. Biol. Bul., 25:79–120

Sherwood, W. L.

1895 The Salamanders Found in the Vicinity of New York City, with Notes upon Extra-limital or Allied Species. Abst. Proc. Linn. Soc. N. Y., No. 7, p. 21–37

Skinner, Alanson

1910 Proc. Staten Island Inst. Arts and Sci., 2(4):226

1916 Capture of an Adult *Amblystoma punctata* on Staten Island. Proc. Staten Island Ass'n Arts and Sci., 5:98

Slevin, J. R.

1928 The Amphibians of Western North America. Occasional Papers of the California Academy of Sciences, XVI, p. 6–152, pls. 1–23

Smallwood, W. M.

1928 Notes on the Food of Some Onondaga Urodela. Copeia, No. 169, p. 89–98

Smith, B. G.

1907 The Breeding Habits of *Amblystoma punctatum* Linn. Amer. Nat., 41:381–90

1907*a* The Life History and Habits of *Cryptobranchus allegheniensis*. Biol. Bul., 13:5–39, figs. 1–14

1910 The Structure of the Spermatophores of *Ambystoma punctatum*. Biol. Bul., 18: 204–11, figs. 1–5

1911 Notes on the Natural History of *Amblystoma jeffersonianum, A. punctatum* and *A. tigrinum*. Bul. Wis. Nat. Hist. Soc., 9:14–27, pls. 1–3, figs. 1–12

1911*a* The Nests and Larvae of Necturus. Biol. Bul., 20:191–200, figs. 1–7

1912 The Embryology of *Cryptobranchus allegheniensis*. Jour. Morph., 23:61–160, pls. 1–2, text figs. 1–52; 23:455–578, pls. 3–10, figs. 57–279

Smith, Louise

1920 Some Notes on *Notophthalmus viridescens*. Copeia, No. 80, p. 22–24

1921 A Note on the Eggs of *Ambystoma maculatum*. Copeia, No. 97, p. 41

Smith, W. H.

1882 Report on the Reptiles and Amphibians of Ohio. Rep't Geol. Surv. Ohio, 4(Pt 1 Zool.):633–734, figs. 1–7

Stejneger, L.

1902 A Salamander New to the District of Columbia. Proc. Biol. Soc. Wash., 15:239–40

———— & Barbour, Thomas

1923 A Check List of North American Amphibians and Reptiles. 2d ed. p. iii–xi, 1–171. Cambridge

1933 A Check List of North American Amphibians and Reptiles. 3d ed. p. v.-xiv, 1–185. Cambridge

Storer, T. I.

1925 A Synopsis of the Amphibia of California. Univ. Cal. Pub. in Zool., 27:1–342, pls. 1–18, 42 text figs.

Strecker, J. K.

1927 Observations on the Food Habits of Texas Amphibians and Reptiles. Copeia, No. 162, p. 6

Surface, H. A.

1913 First Report on the Economic Features of the Amphibians of Pennsylvania. Zool. Bul. Div. Zoology. Penna. Dep't of Agriculture, 3:68–152, pls. 1–11, text figs. 1–25

Townsend, C. H.

1882 Habits of the *Menopoma*. Amer. Nat., 16:139–40

Uhlenhuth, Eduard

1921 Experimental Production of Gigantism by Feeding the Anterior Lobe of the Hypophysis. Jour. Gen. Physio, 3:347–65, figs. 1–5

Unterstein, W.

1929 Bemerkungen zur Fortpflanzung von *Desmognathus fuscus* Raf. Sitzungs. Gesella. Naturf. Freunde., Nr. 8–10, p. 245–49, figs. 1–3

Verrill, A. E.

1862 Notice on the Eggs and Young of a Salamander (*D. fusca* Baird) from Maine. Ann. Nat. Hist. Bost. 9:253

Viosca, Percy

1924 Observations on the Life-History of *Ambystoma opacum*. Copeia, No. 134, p. 86–88

Waite, F. C.

1907 Specific Name of *Necturus maculosus*. Amer. Nat. 41:23–30

Walker, C. F.

1933 Some New Amphibian Records for Ohio. Copeia, No. 4, p. 224

Warfel, H. E.

1936 Notes on the Occurrence of *Necturus maculosus* (Rafinesque) in Massachusetts. Copeia, No. 4, p. 237

Weber, J. A.

1928 Herpetological observations in the Adirondack Mountains, New York. Copeia, No. 169, p. 106–12

Wilder, H. H.

1899 *Desmognathus fuscus* (Rafinesque) and *Spelerpes bilineatus* (Green). Amer. Nat., 33:231–46, figs. 1–26

1904 The Early Development of *Desmognathus fusca*. Amer. Nat., 38:117–25, figs. 1–5

Wilder, I. W.

1913 The Life History of *Desmognathus fusca.* Biol. Bul., 24(4):251–92, figs. 1–14; (5):293–342, figs. 15–33

1917 On the Breeding Habits of *Desmognathus fusca.* Biol. Bul., 32:13–20, 1 fig.

1923 Spermatophores of *Desmognathus fusca.* Copeia, No. 121, p. 88–92

1924 The Development History of *Eurycea bislineata* in Western Mass. Copeia, No. 133, p. 77–80

1924*a* The Relation of Growth to Metamorphosis in *Eurycea bislineata* (Green). Jour. Exp. Zool., 40:1–112, figs. 1–18

———— & Peabody, E. B.

1924 Hermaphroditism in *Eurycea bislineata.* Biol. Bul., 47:345–67

Wilmott, G. B.

1933 The Salamanders of Staten Island, N. Y. in 1931. Staten Island Inst. Arts and Sci., 6:161–64

Wright, A. H.

1908 Notes on the Breeding Habits of *Amblystoma punctatum.* Biol. Bul., 14:284–89

1918 Notes on *Clemmys.* Proc. Biol. Soc. Wash., 31:56

———— & Allen, A. A.

1909 The Early Breeding Habits of *Amblystoma punctatum.* Amer. Nat., 43:687–92

1913 Field Note-book of Fishes, Amphibians, Reptiles and Mammals. Ithaca, N. Y.

———— & Haber, J. M.

1922 The Carnivorous Habits of the Purple Salamander. Copeia, No. 105, p. 31–32

———— & Moesel, Julia

1919 The Salamanders of Monroe and Wayne Counties, N. Y. Copeia, No. 72, p. 63–64

Yarrow, H. C.

1882 Check List of North American Reptilia and Batrachia, with Catalogue of Specimens in U. S. National Museum. Bul. U. S. Nat. Mus., 24, p. 1–249

Anonymous

1852 5th Ann. Rep't State Cab. Nat. Hist., p. 21–24

1854 7th Ann. Rep't State Cab. Nat. Hist., p. 26

1873 23d Ann. Rep't State Cab. Nat. Hist., p. 21

1873*a* 25th Ann. Rep't N. Y. State Mus. Nat. Hist., p. 15

1875 27th Ann. Rep't N. Y. State Mus. Nat. Hist., p. 23

1878 29th Ann. Rep't N. Y. State Mus. Nat. Hist., p. 20

1888 41st Ann. Rep't State Mus. Nat. Hist., p. 29

1893 46th Ann. Rep't N. Y. State Mus., p. 22

1901 53d Ann. Rep't N. Y. State Mus., p. 169

1907 60th Ann. Rep't N. Y. State Mus., p. 99

1908 61st Ann. Rep't N. Y. State Mus., p. 132

1909 62d Ann. Rep't N. Y. State Mus., p. 99–100

1912 65th Ann. Rep't N. Y. State Mus., p. 101

1918 70th Ann. Rep't N. Y. State Mus., p. 87

1919 72d Ann. Rep't N. Y. State Mus., p. 94

1890 Proc. Nat. Sci. Ass'n Staten Island, 2:47

1910 Proc. Staten Island Inst. Arts and Sci., 2(4):226–27

1920 Proc Staten Island Ass'n Arts and Sci., 7:59

1923 Proc Staten Island Ass'n Arts and Sci., 1(4):128–29

1924 Proc. Staten Island Ass'n Arts and Sci., 2(2–4):156

1931 Proc. Staten Island Inst. Arts and Sci., 6(1):42

1927 Salamander Found Two Feet Underground at Shippen. Guide to Nature, 19:190

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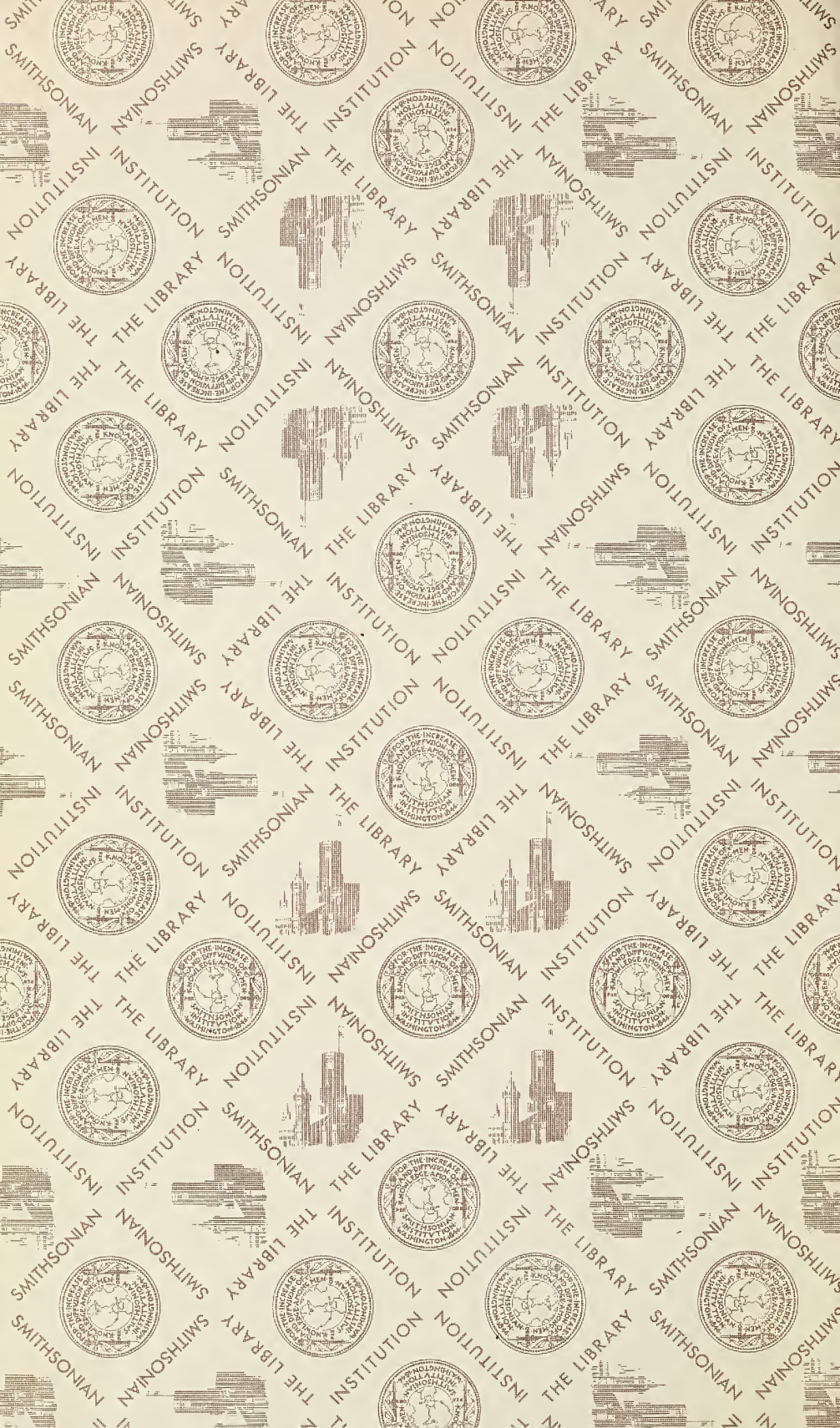
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